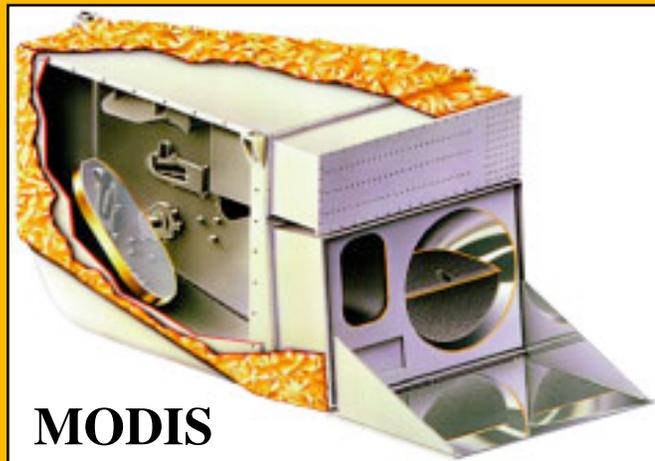


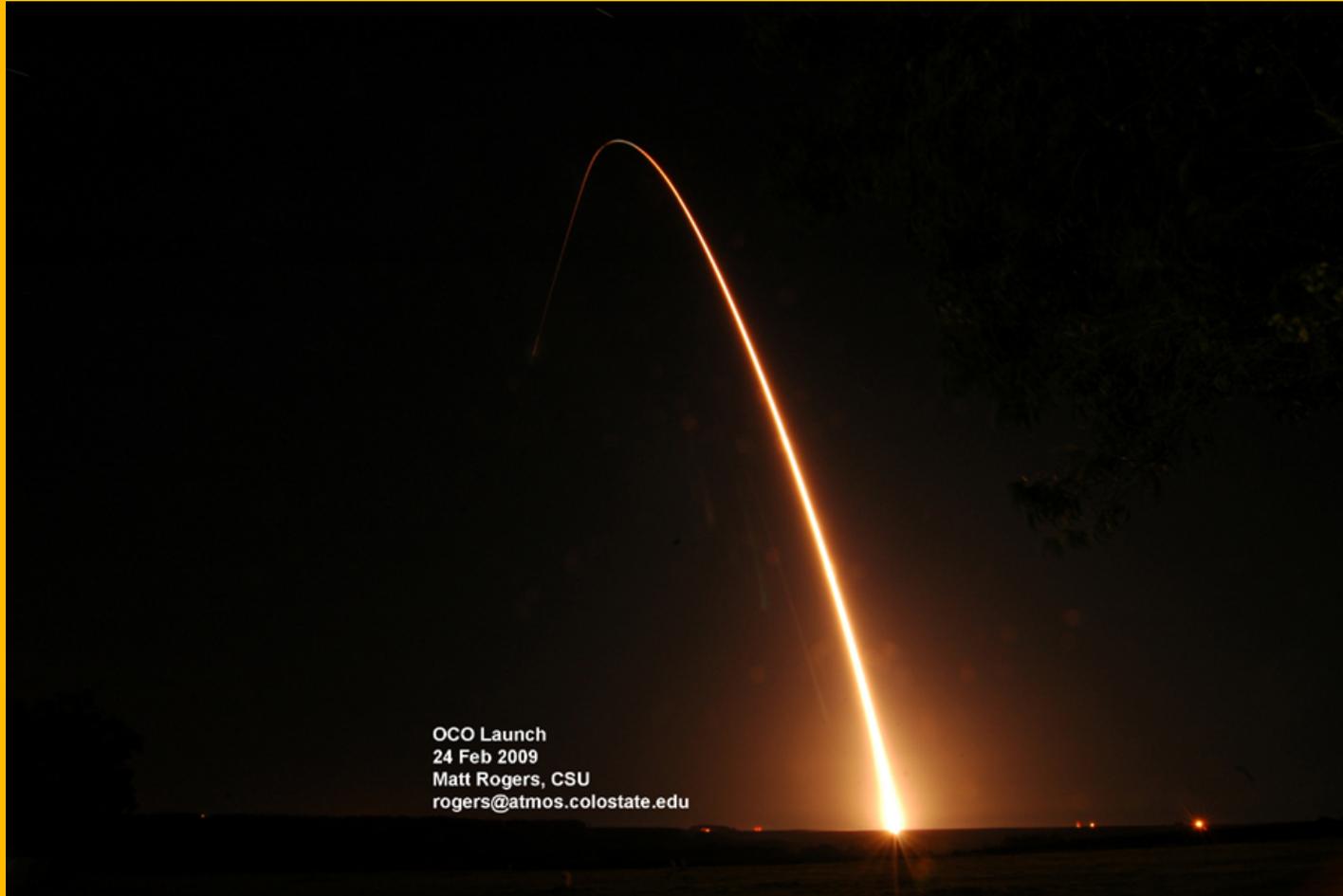
Satellites Aerosol Measurements -- One Piece of the Climate Forcing Picture

Ralph Kahn**
NASA Goddard Space Flight Center



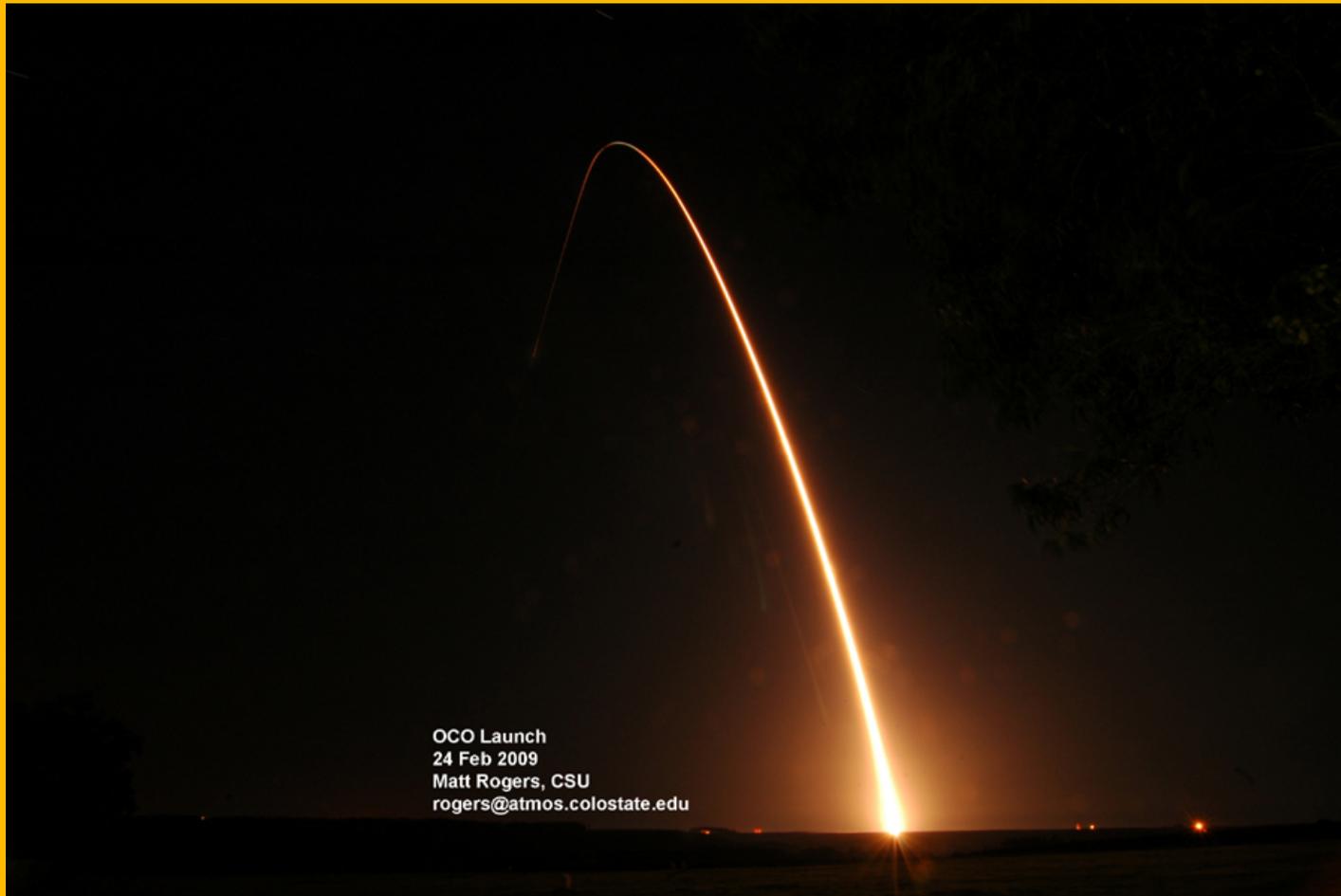
**With contributions from the Satellite Aerosol, and Satellite Aerosol Validation Communities

OCO – The Orbiting Carbon Observatory



Lost near Antarctica, 24 Feb. 2009, 3 minutes after launch, due to fairing release failure

OCO – The Orbiting Carbon Observatory



Lost near Antarctica, 24 Feb. 2009, 3 minutes after launch, due to fairing release failure

Reminding us to make good use of the data we have...

IPCC Assessments of Aerosol Contribution to Climate Forcing

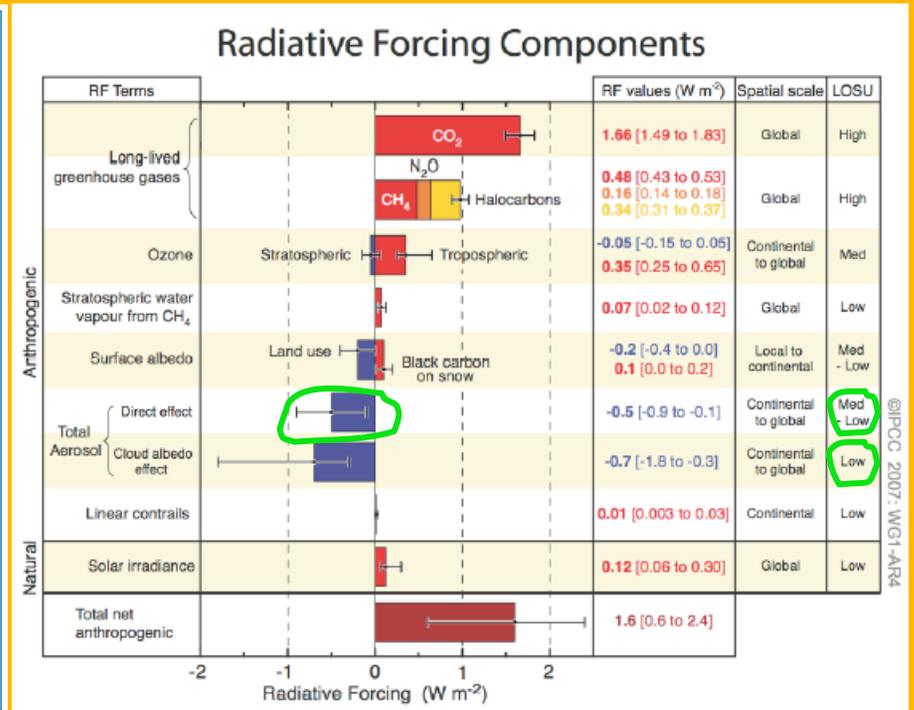
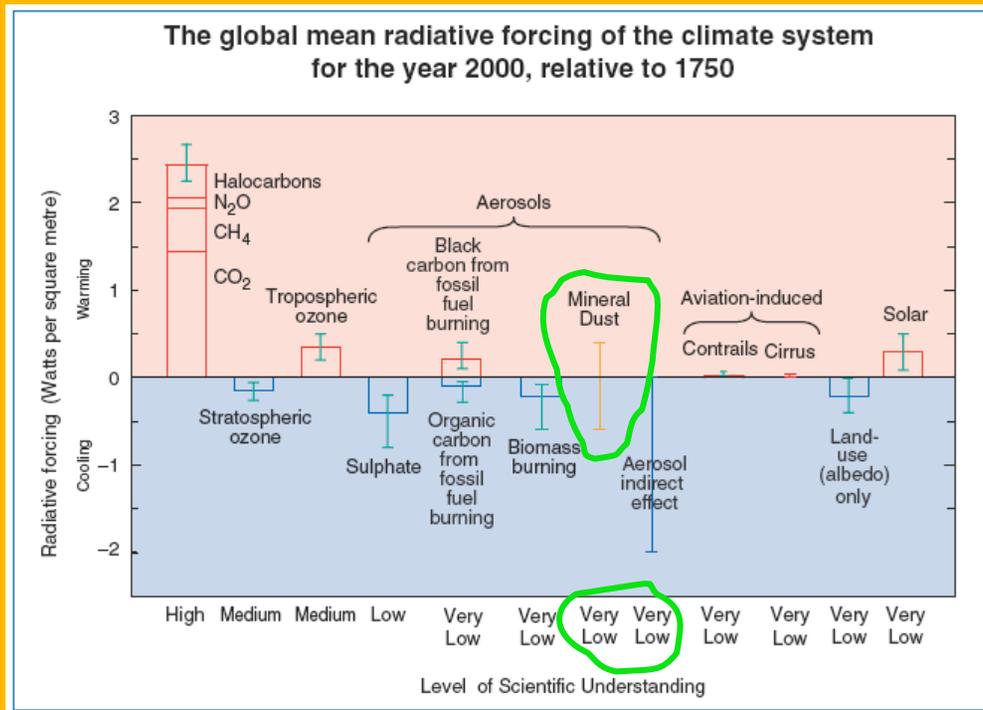


FIGURE SPM-2. Global-average radiative forcing (RF) estimates and ranges in 2005 for anthropogenic carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O) and other important agents and mechanisms, together with the typical geographical extent (spatial scale) of the forcing and the assessed level of scientific understanding (LOSU). The net anthropogenic radiative forcing and its range are also shown. These require summing asymmetric uncertainty estimates from the component terms, and cannot be obtained by simple addition. Additional forcing factors not included here are considered to have a very low LOSU. Volcanic aerosols contribute an additional natural forcing but are not included in this figure due to their episodic nature. Range for linear contrails does not include other possible effects of aviation on cloudiness. {2.9, Figure 2.20}

**2001 Report
(Pre-EOS)**

**2007 Report
(EOS + ~6 years)**

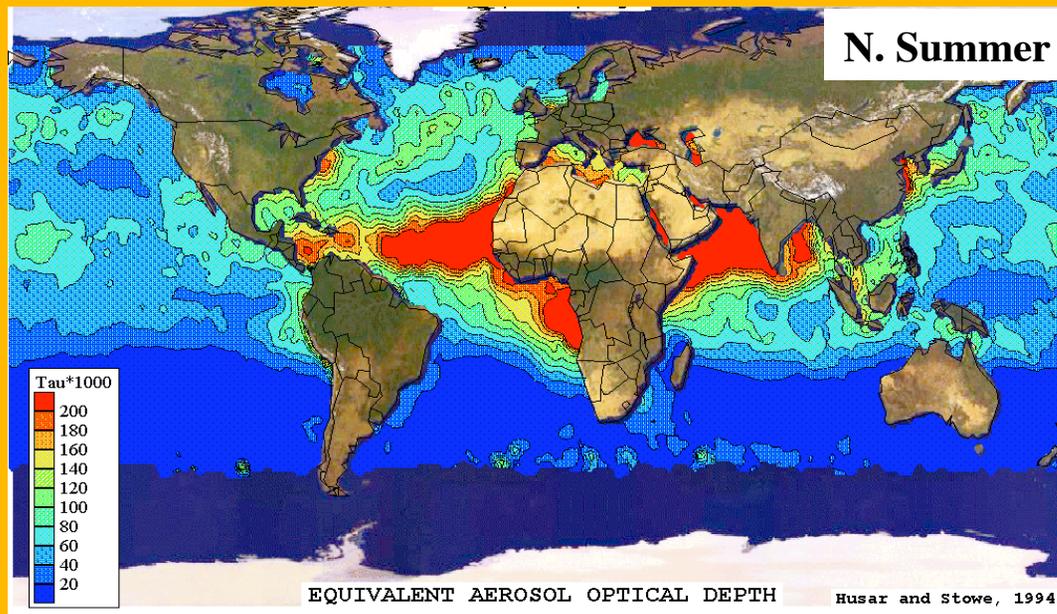
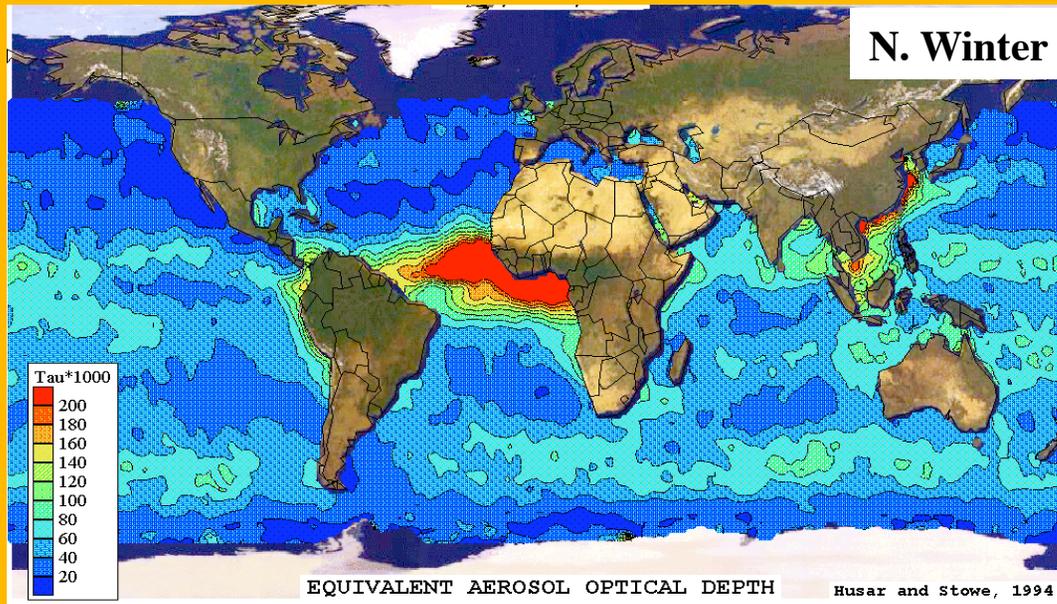
Aerosol Contribution to Climate Forcing

- Cloud-free, global, *over-ocean*, vis, TOA Direct ARF relative to zero aerosol: -5.5 ± 0.2 W/m²
This is a *measurement-based* value, with *uncertainty defined as diversity* among estimates
- Taking 20% of aerosol to be anthropogenic, the *human-induced component* is: -1.1 ± 0.4 W/m²
- Total, global TOA ARF relative to pre-industrial (i.e., anthropogenic): -1.3 (-2.2 to -0.5) W/m²
This is a *model-based* value, with *uncertainty defined as diversity* among estimates
- The models tend to agree on global AOD, but differ on *regional-scale AOD*, aerosol *SSA*, and *vertical distribution*
- To determine *surface* DARF, *regional-scale AOD*, aerosol *SSA* and *vertical distribution*, and *surface albedo* are all *critical*. For anthropogenic component, also *source attribution*
- Quantifying from space aerosol *indirect effects* on clouds is yet more challenging...

Bottom line for *this* “satellite contribution” talk:

Instantaneous AOD and *SSA* uncertainty upper bounds for ~ 1 W/m² DARF accuracy: ~ 0.02
... use satellites to *help constrain model* aerosol sources, processes, transports, & sinks

AVHRR 1-Channel NOAA AOT



- AOT Over Water only
- Globe ~ **Every 2 days**

AVHRR 2-Channel GISS AOT

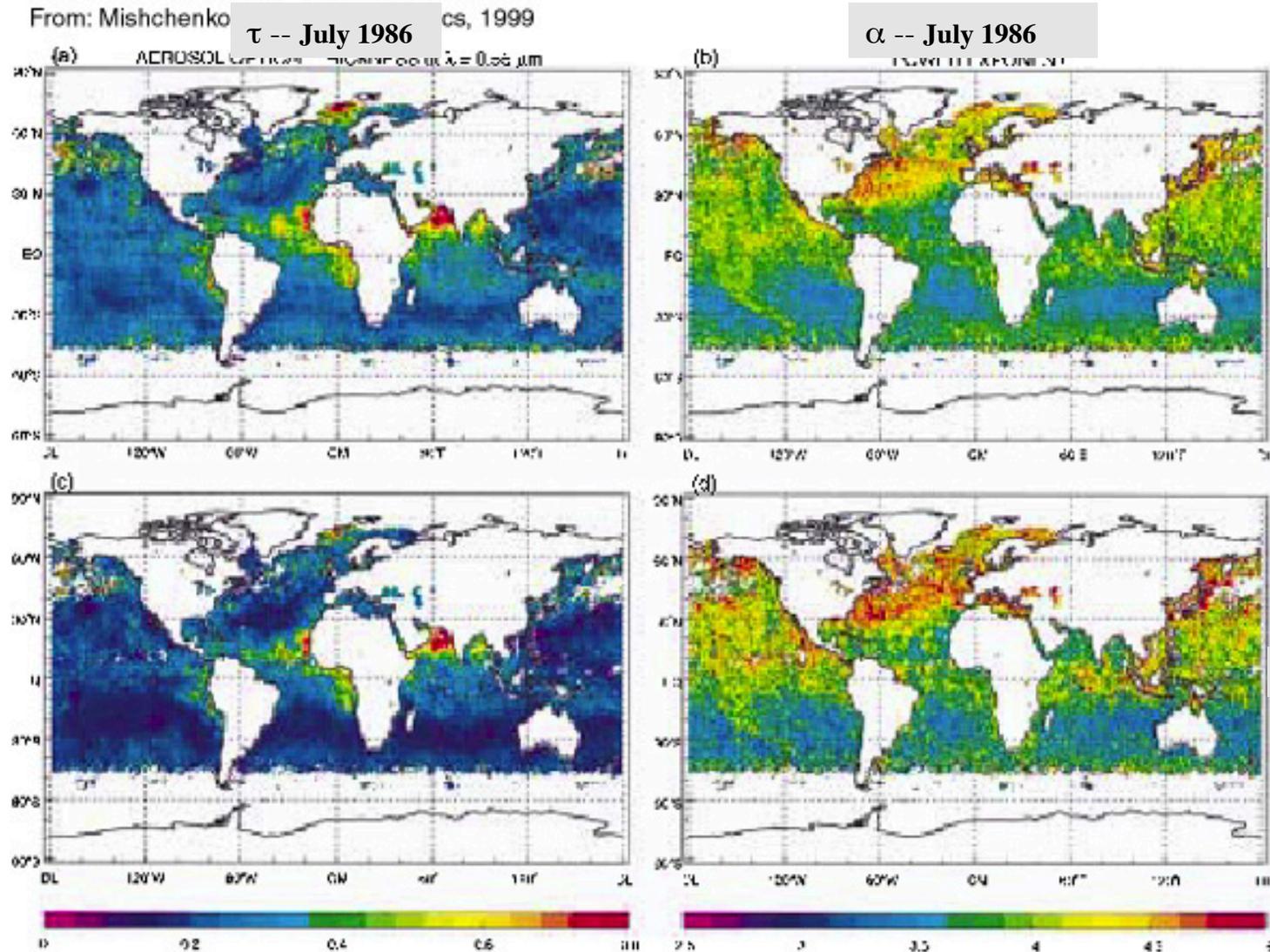
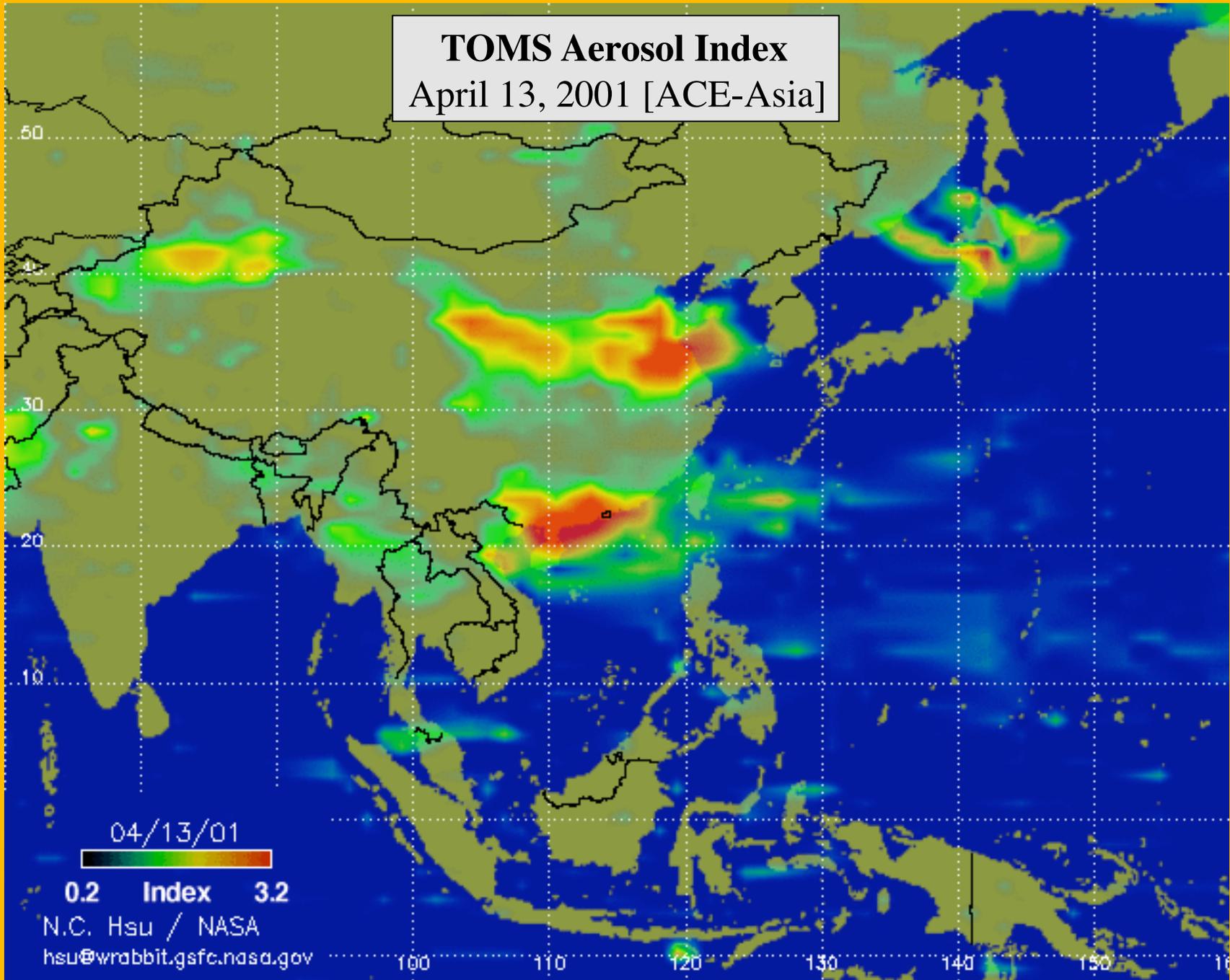
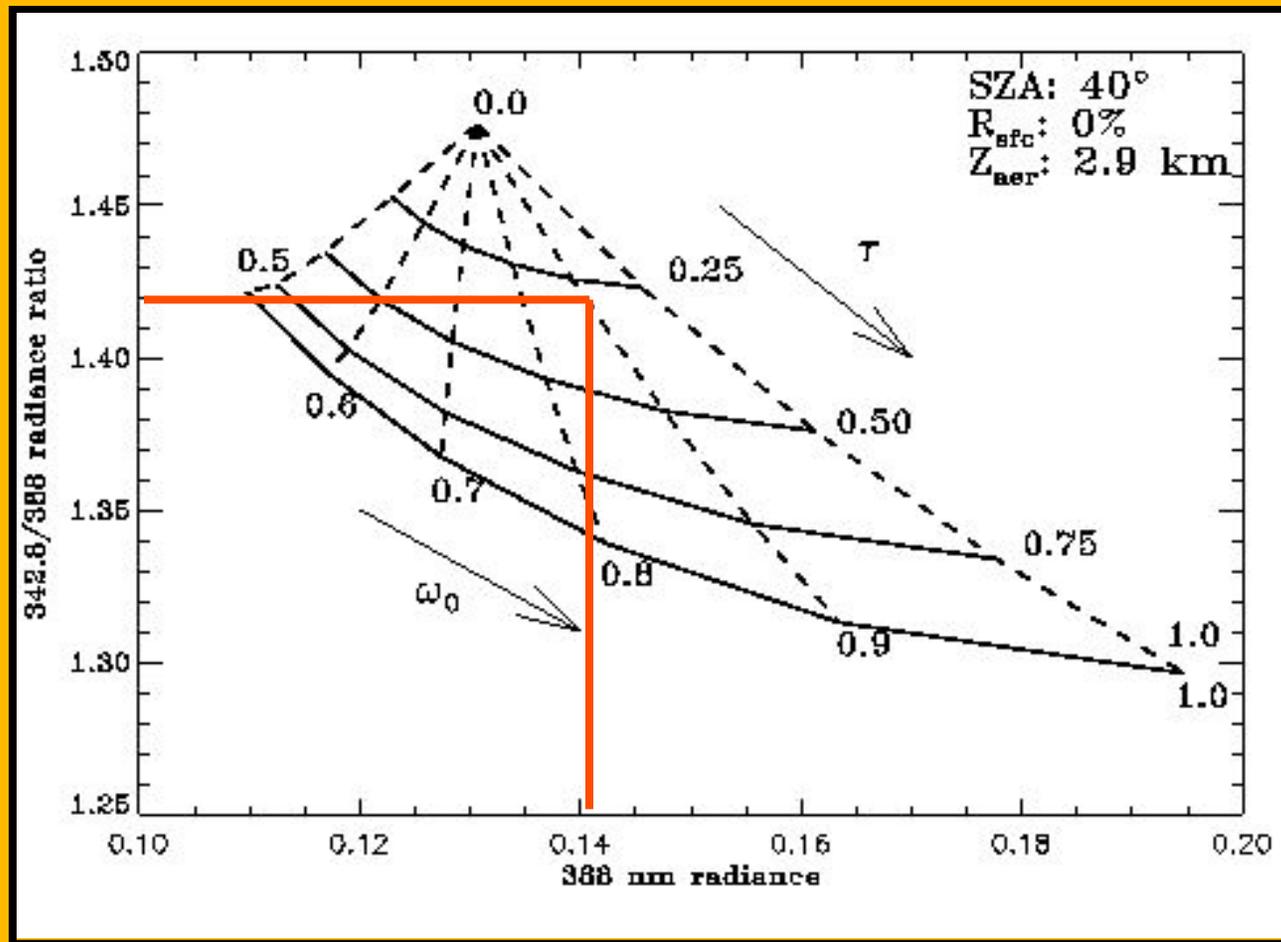


Fig. 6. (a) and (b) Monthly mean optical thickness (τ) and optical-thickness-weighted power exponent (α) for July 1986 derived with the benchmark atmosphere-ocean model and the standard ISCCP cloud-detection scheme. (c) and (d) As in panels (a) and (b) but with a modified cloud-detection scheme that retains only pixels with channel-5 temperatures warmer than the respective composite values.

TOMS Aerosol Index
April 13, 2001 [ACE-Asia]



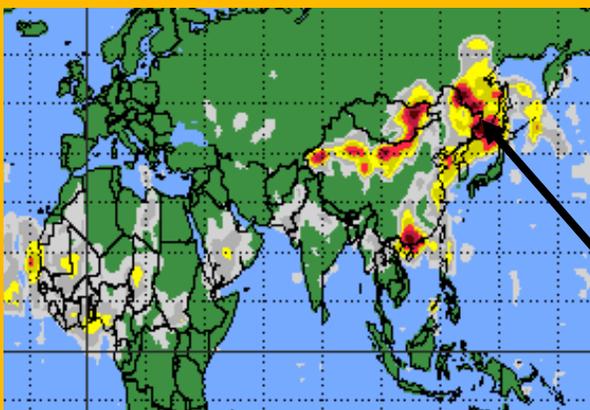
OMI AOT and SSA Retrieval Approach



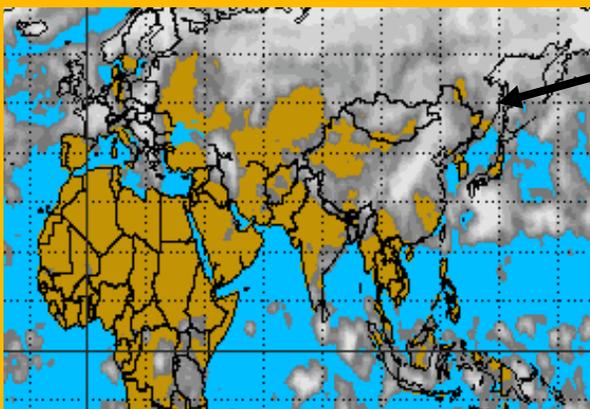
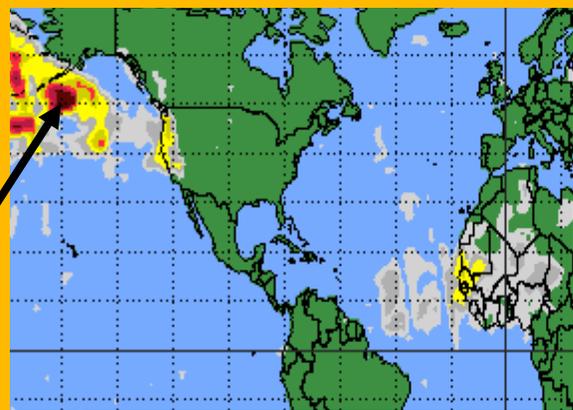
- Aerosol *reduces* the TOA spectral contrast of the Rayleigh-scattering gas atmosphere.
- Higher SSA (less absorbing) *increases* the TOA Radiance, **decreases contrast**.
- For absorbing aerosols, *elevation* also matters.
- Land **Surface** (even desert) is **usually dark** in the UV

TOMS Near-UV Aerosol Products

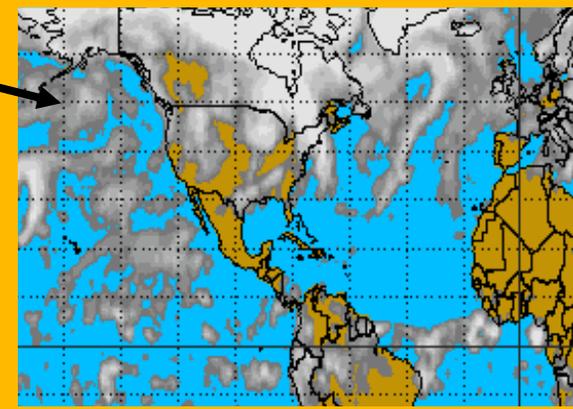
April 2001 [ACE-ASIA]



Aerosol Index

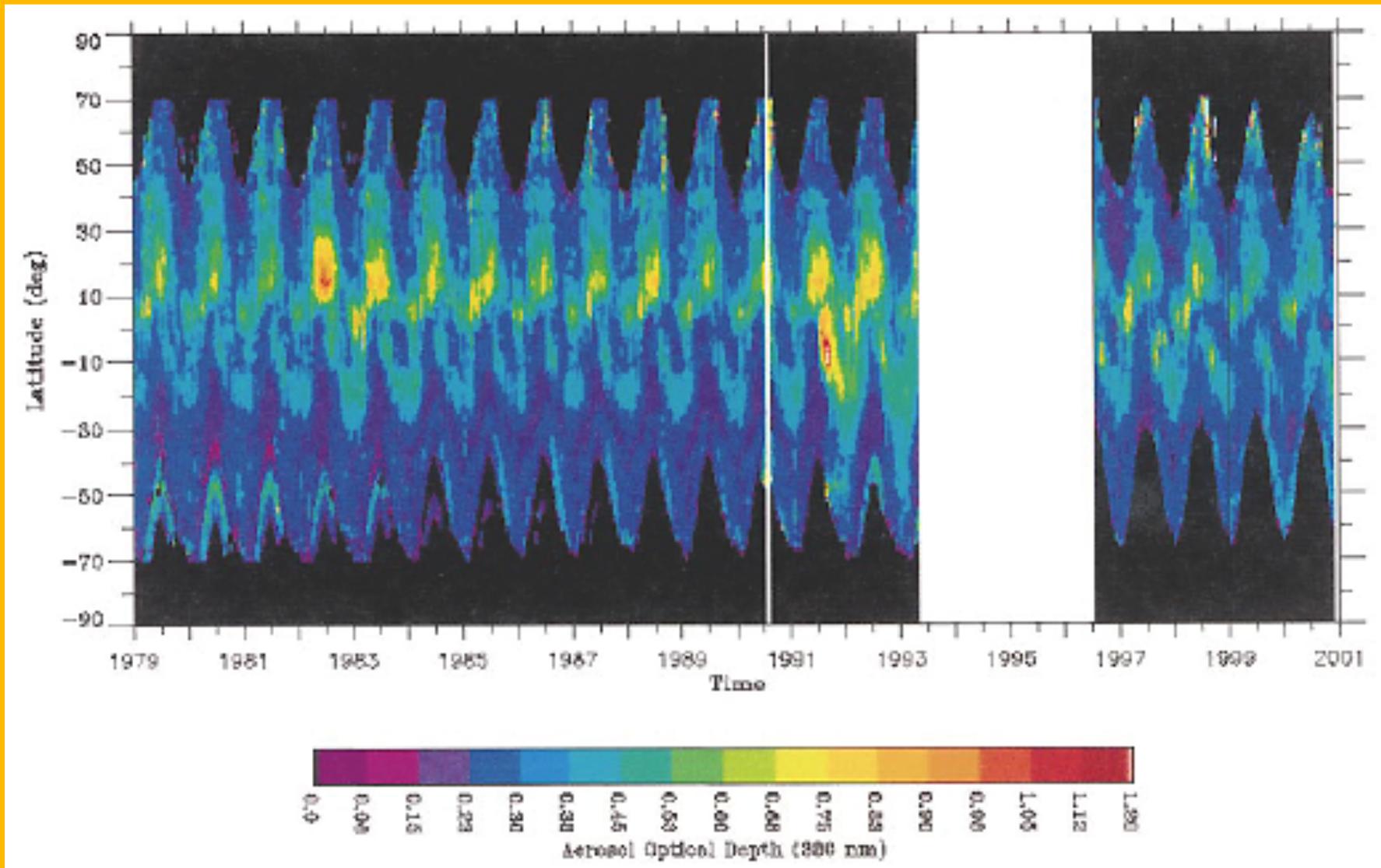


Reflectivity



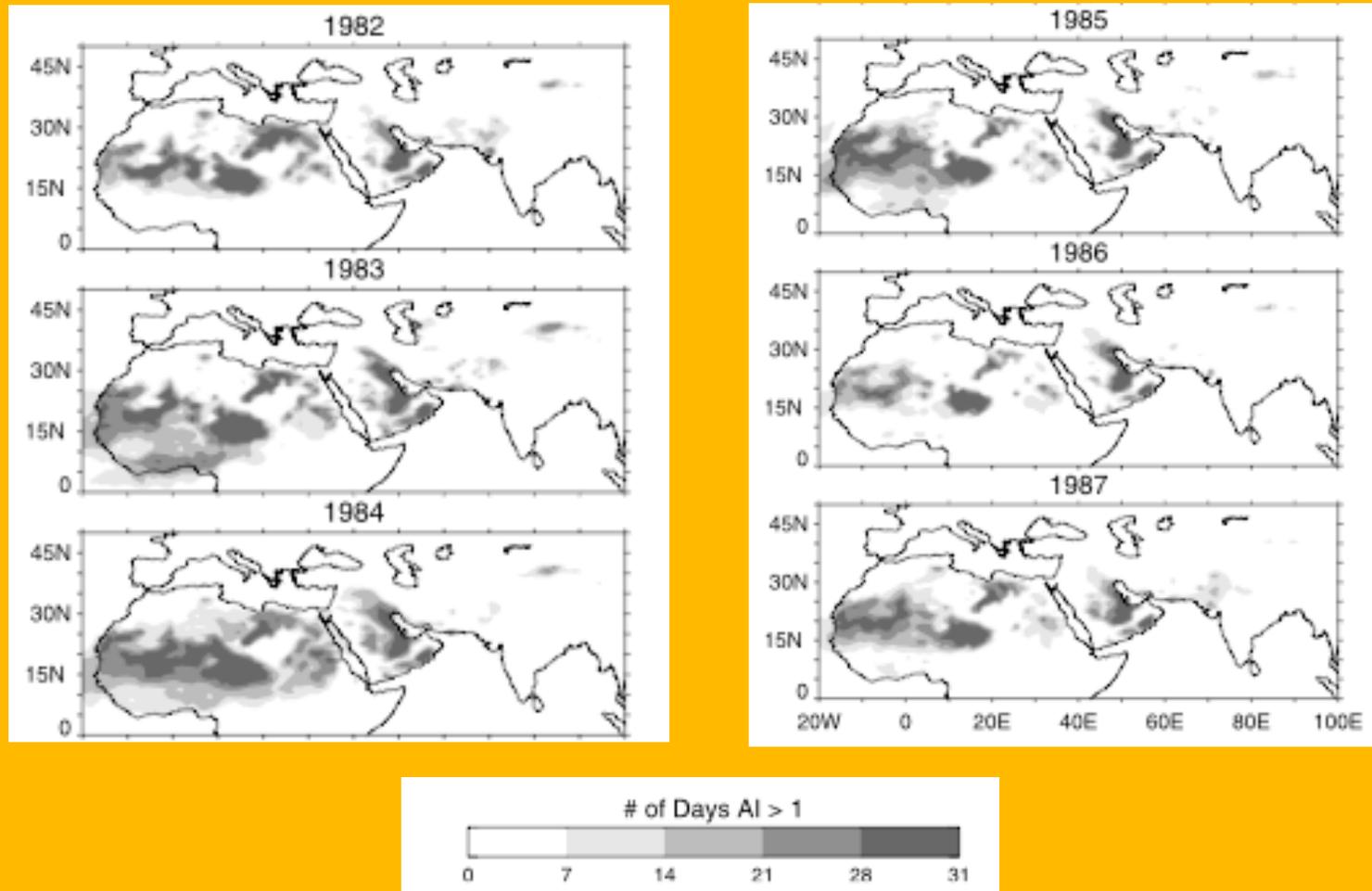
Aerosols
over
clouds

TOMS Aerosol Index - 1979-2001 Weekly, Zonal, 1°x1° Average Global Record



From: *Torres et al, JAS, 2002*

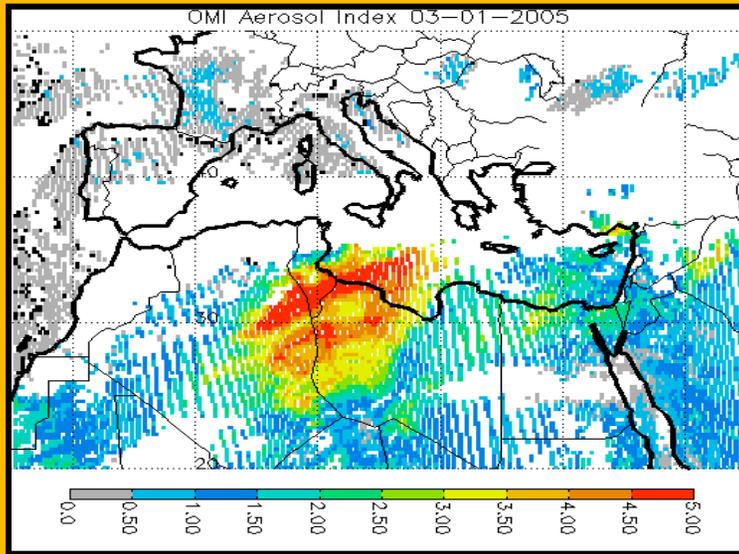
TOMS Aerosol Index - North African Dust Source Inter-annual Variations



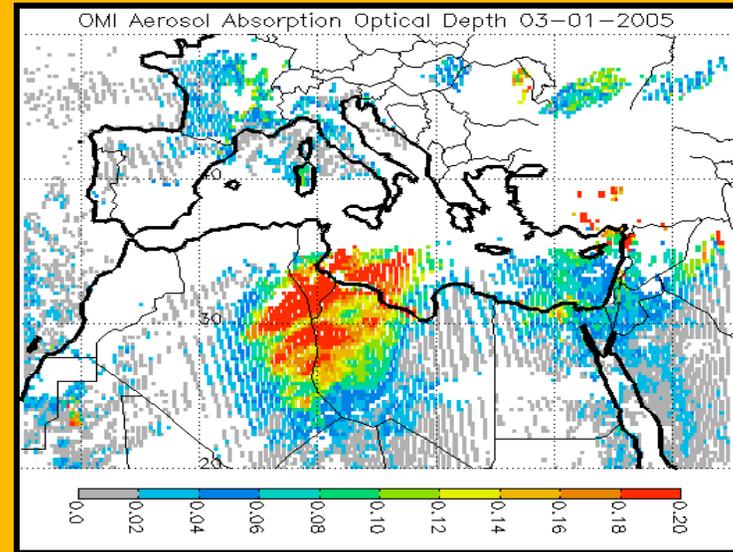
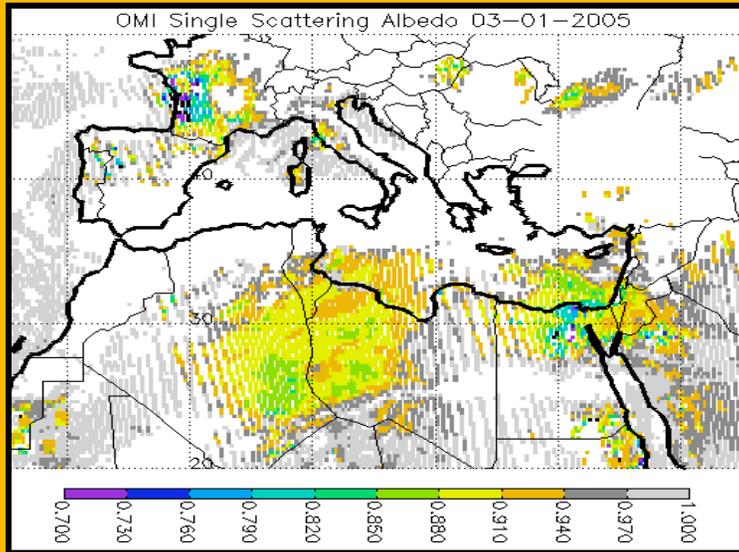
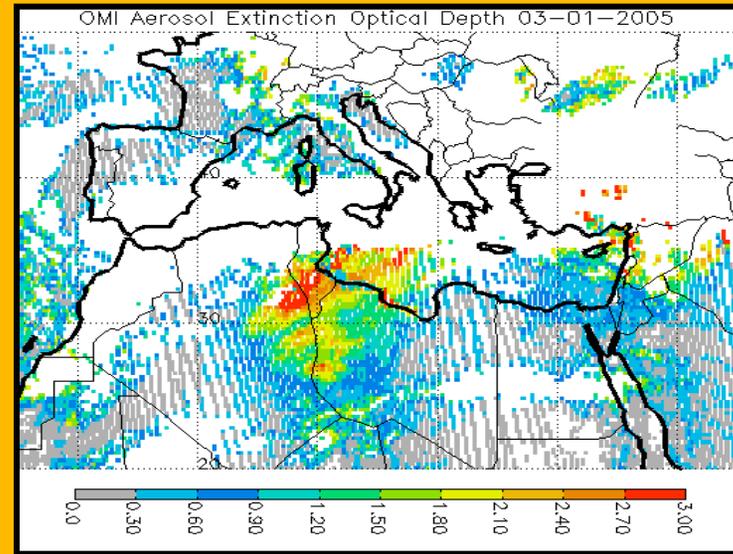
From: *Prospero et al*, Rev. Geophys. 2002

OMI Near UV Aerosol Products

AI



Extinction AOD



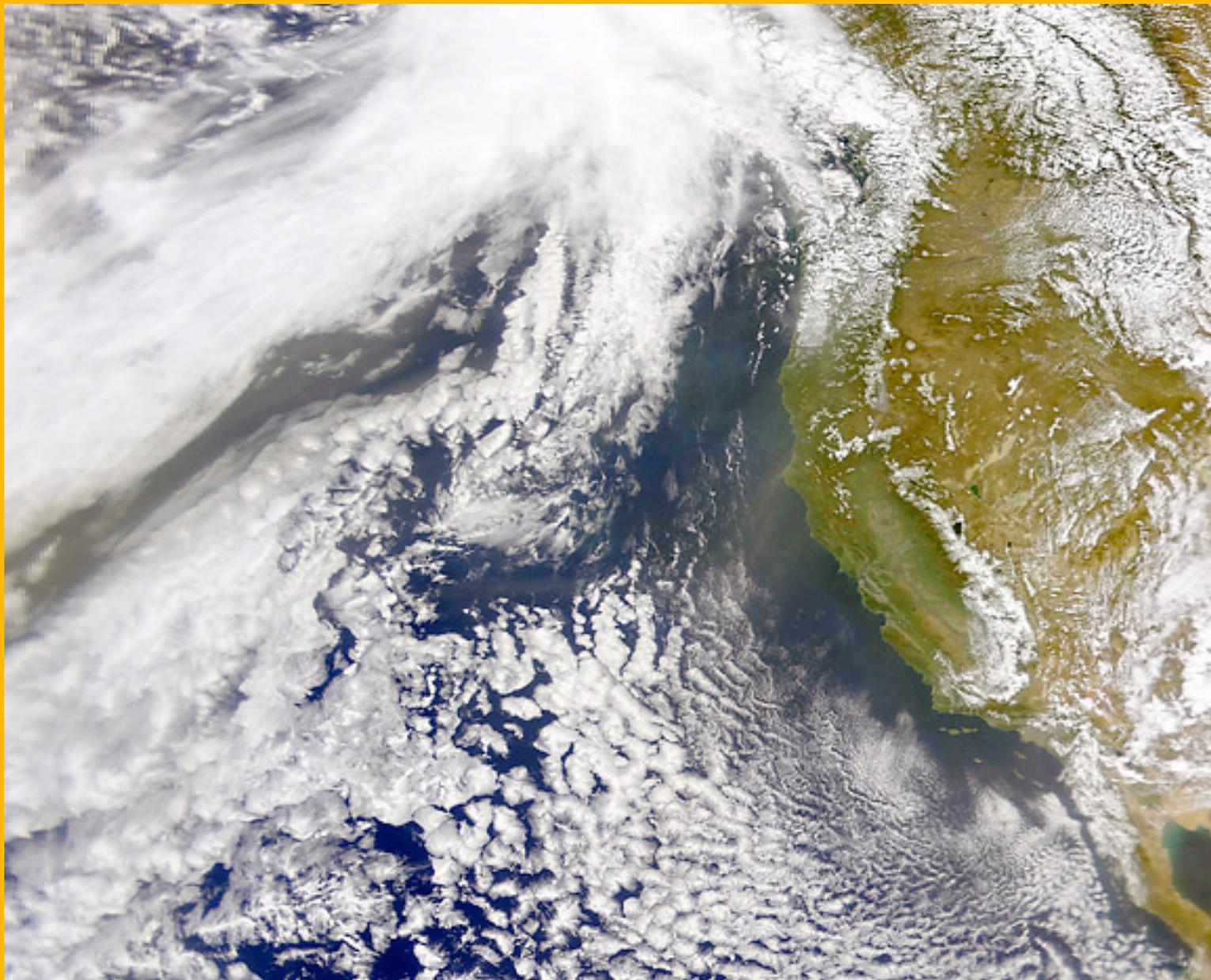
SSA

Absorption Optical Depth

March 01, 2005

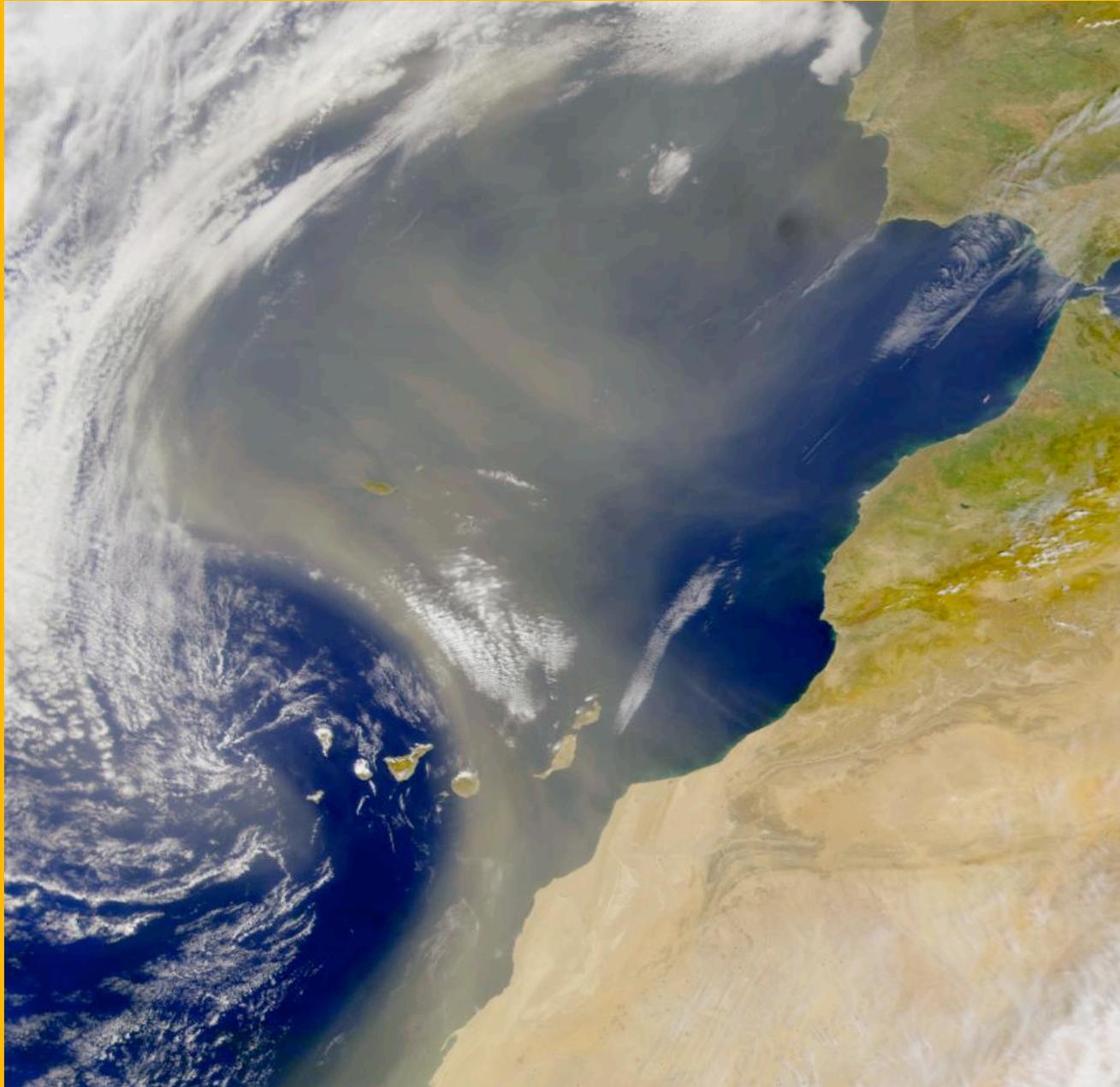
From: Omar Torres

SeaWiFS Dust Transported from China - 04/25/98



Source: *SeaWiFS Web Site*

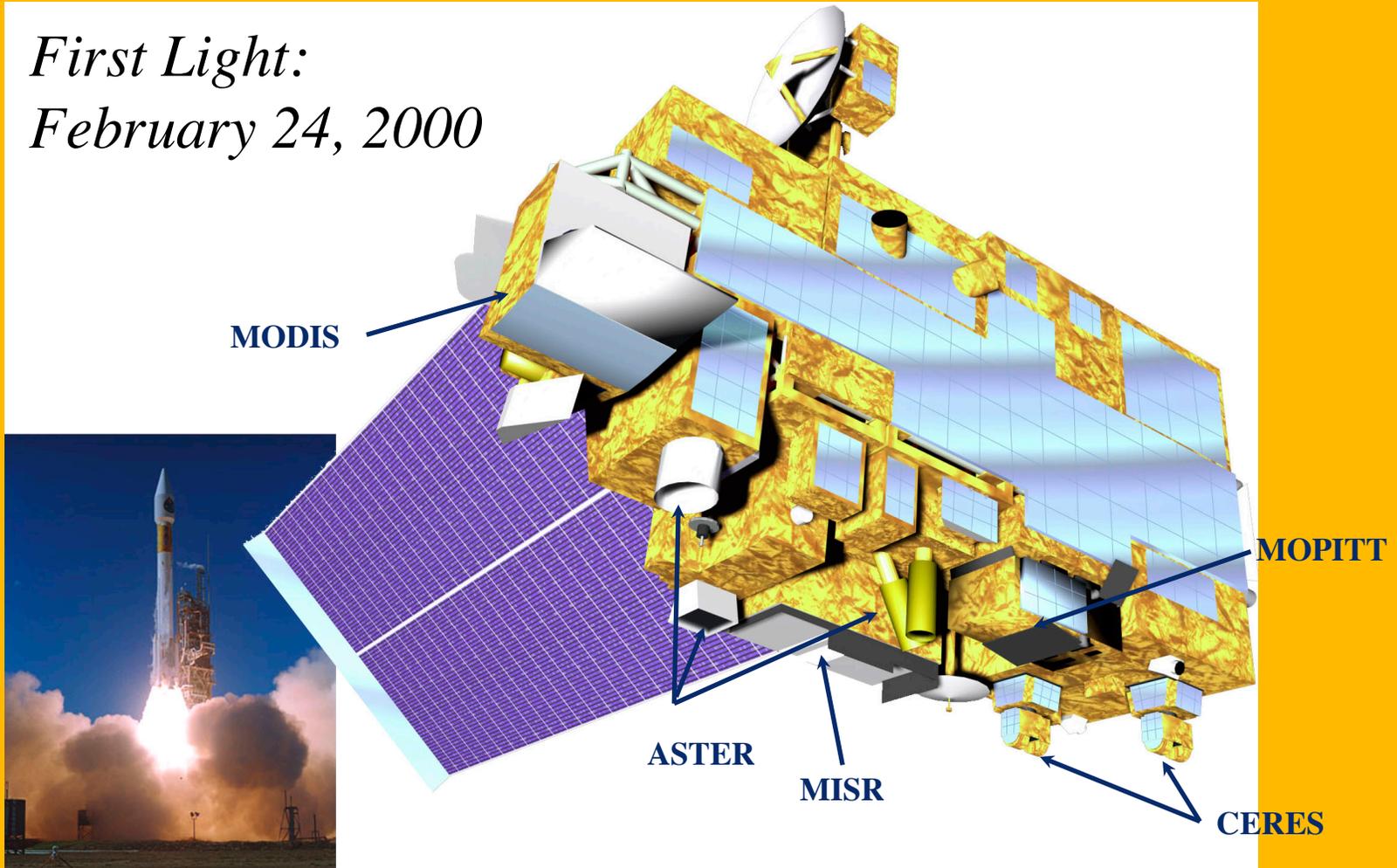
SeaWiFS Sahara Dust over Canary Islands, 03/06/98



Source: *SeaWiFS Web Site*

The NASA Earth Observing System's Terra Satellite

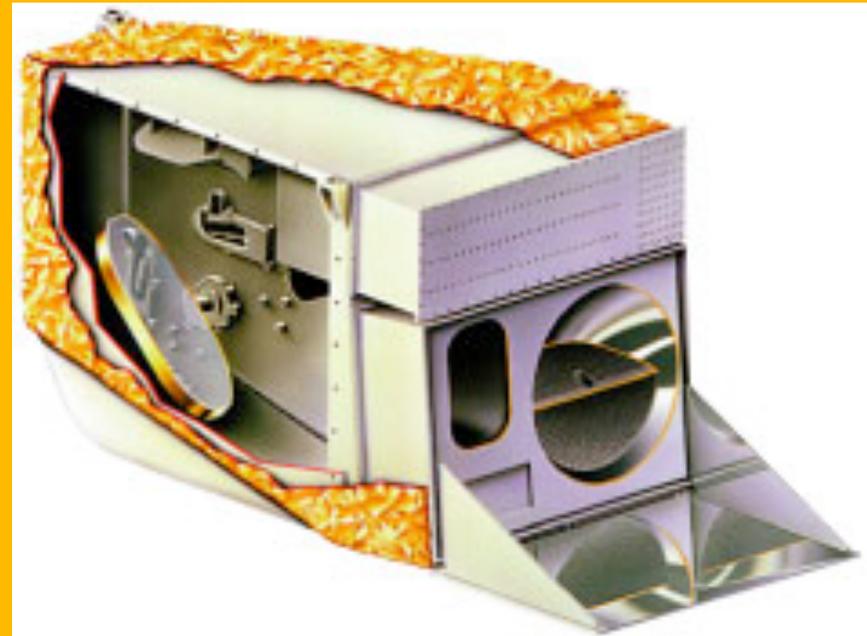
*First Light:
February 24, 2000*



Source: Terra Project Office / NASA Goddard Space Flight Center

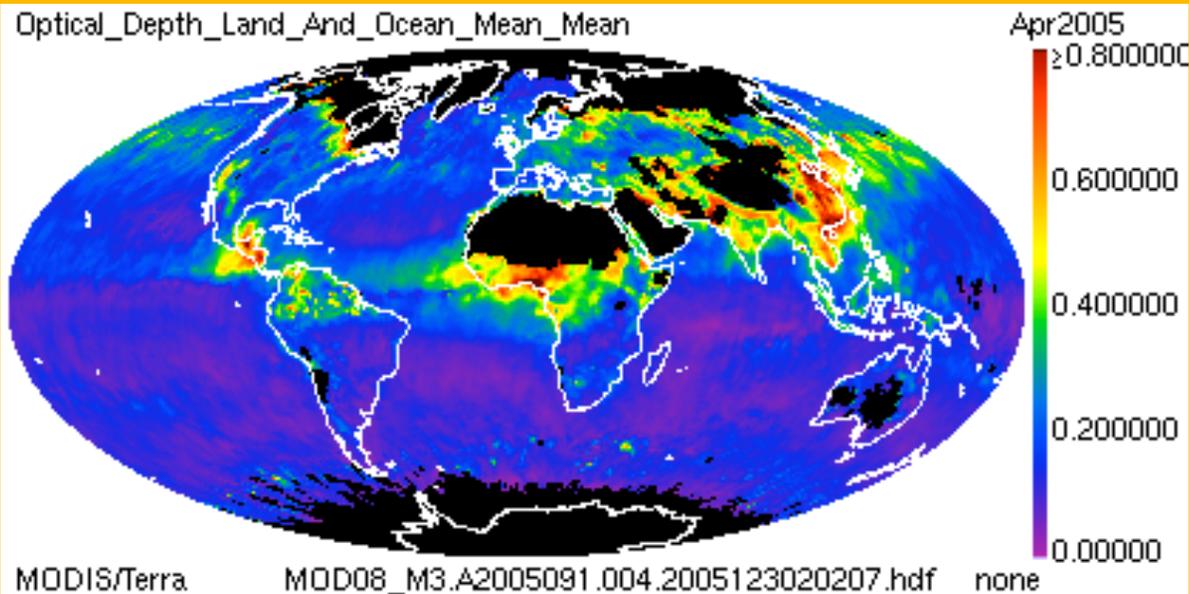
MODerate-resolution Imaging Spectroradiometer [MODIS]

- NASA, Terra & Aqua
 - launches 1999, 2001
 - 705 km polar orbits, descending (10:30 a.m.) & ascending (1:30 p.m.)
- Sensor Characteristics
 - 36 spectral bands ranging from 0.41 to 14.385 μm
 - cross-track scan mirror with 2330 km swath width
 - Spatial resolutions:
 - 250 m (bands 1 - 2)
 - 500 m (bands 3 - 7)
 - 1000 m (bands 8 - 36)
 - 2% reflectance calibration accuracy
 - onboard solar diffuser & solar diffuser stability monitor



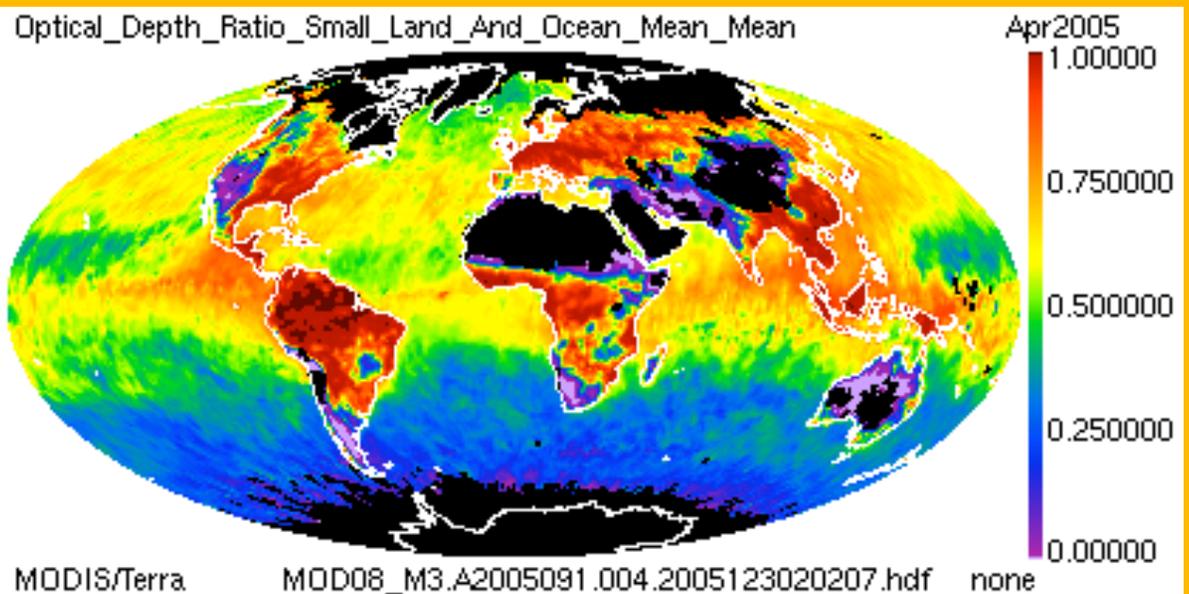
- Improved over AVHRR:
- Calibration
 - Spatial Resolution
 - Spectral Range & # Bands

MODIS Monthly Global Aerosol Products



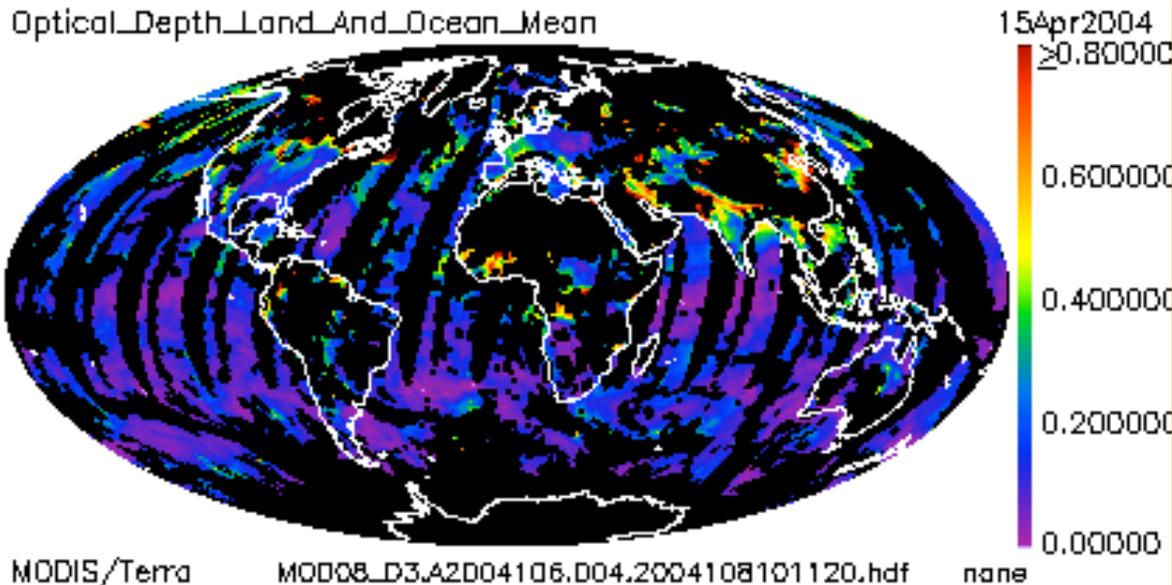
Mid-vis AOT

- Water & some Land
- Globe ~ **Every 2 days**
- ~ 10:30 AM & 1:30 PM



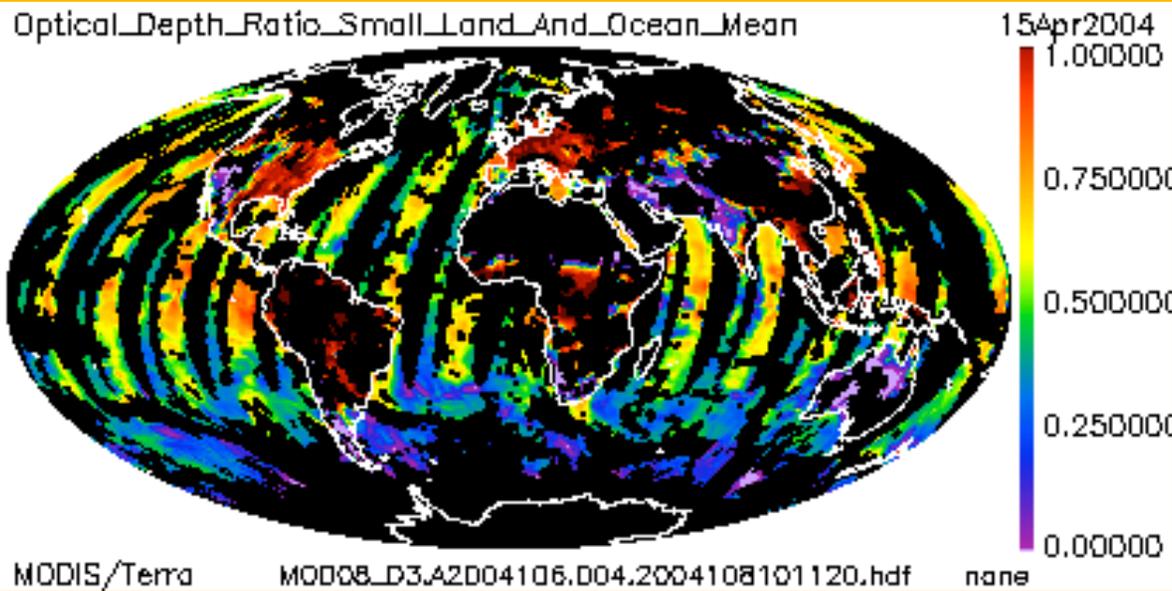
- **Fine/Coarse Ratio**
- Sensitivity to **PM₁₀**

MODIS Daily Aerosol Products



Mid-vis AOD

- Water & some Land
- Globe ~ **every 2 days**
- ~ 10:30 AM & 1:30 PM

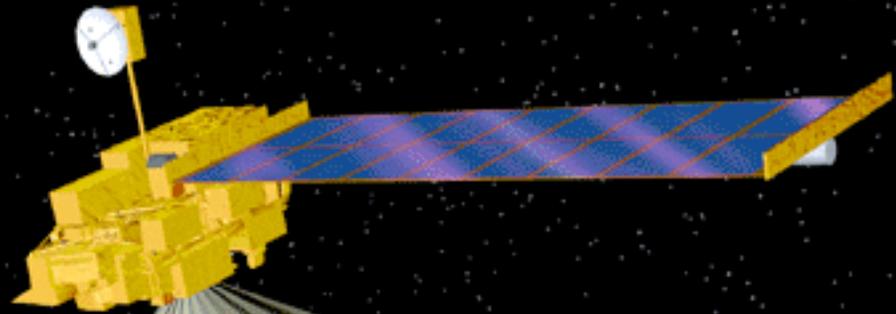


Fine/Coarse Ratio

Direct Downlink

Multi-angle Imaging SpectroRadiometer

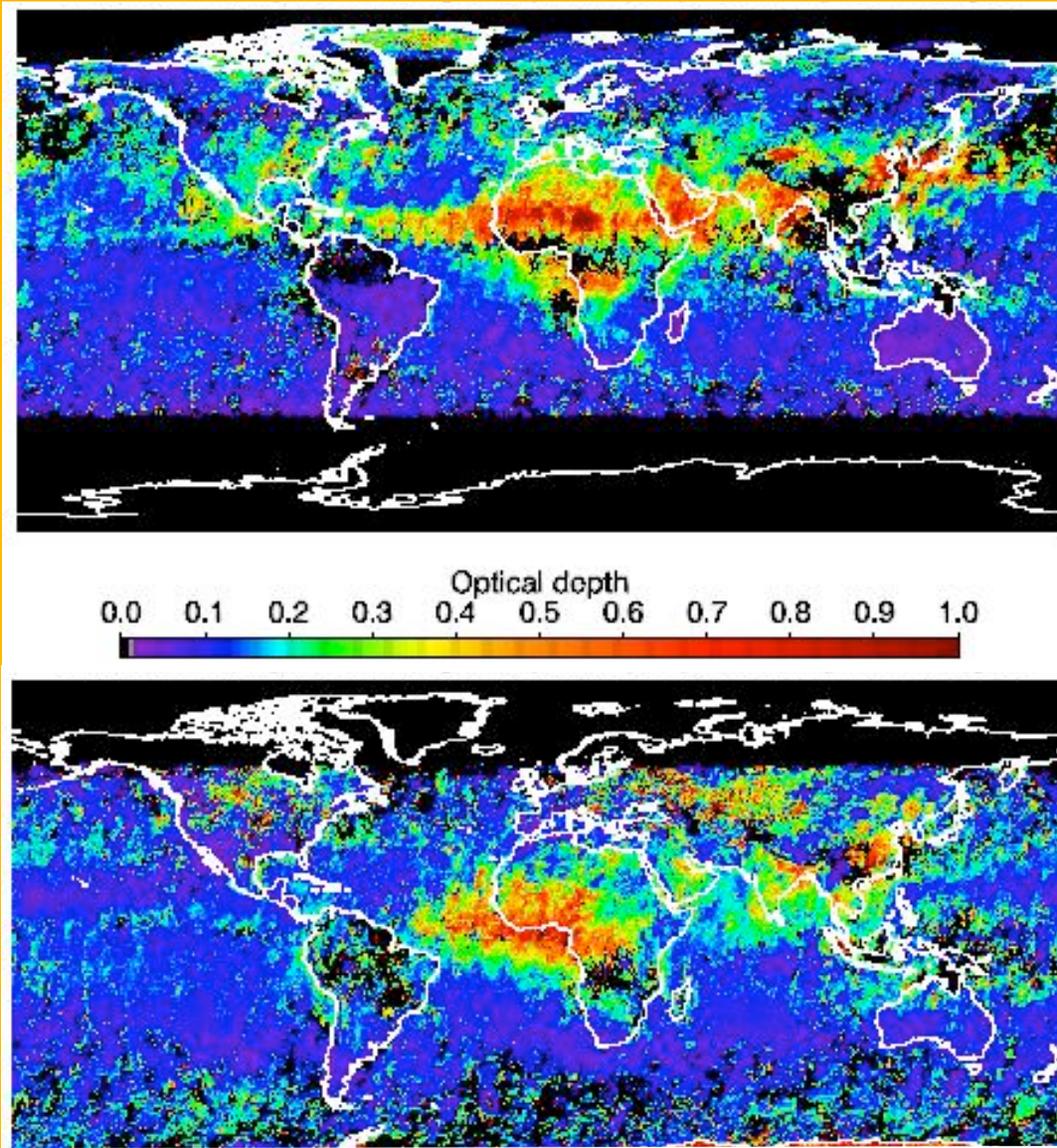
MISR 



<http://www-misr.jpl.nasa.gov>

- Nine CCD push-broom cameras
- Nine view angles at Earth surface:
70.5° forward to 70.5° aft
- Four spectral bands at each angle:
446, 558, 672, 866 nm
- *Studies Aerosols, Clouds, & Surface*

MISR Monthly Global Aerosol Mid-VIS AOT

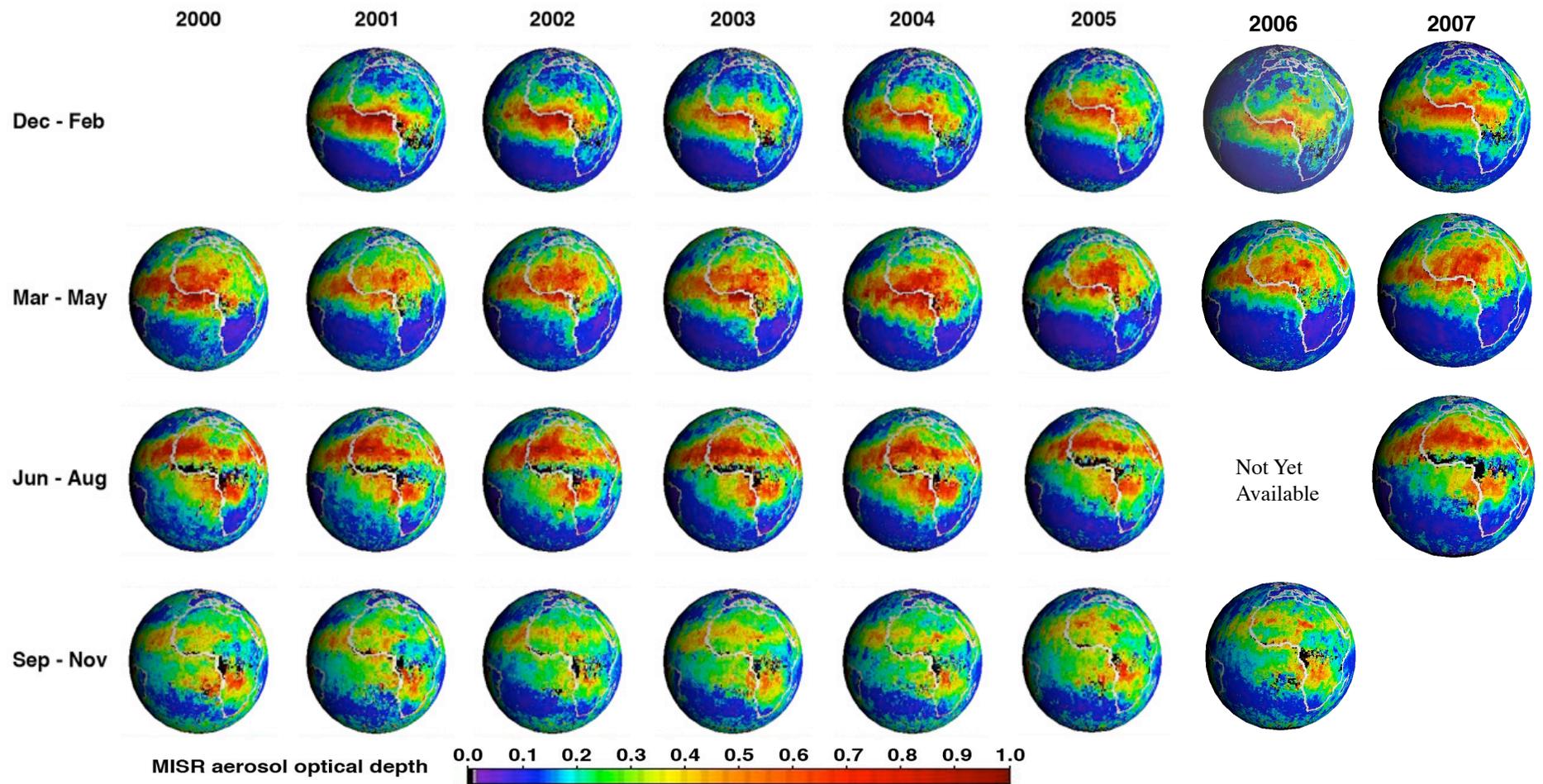


July 2005

- Land & Water
- **Bright Surfaces**
- Globe ~ weekly
- ~ 10:30 AM
- [+ **particle size, shape, SSA constraints**]

January 2005

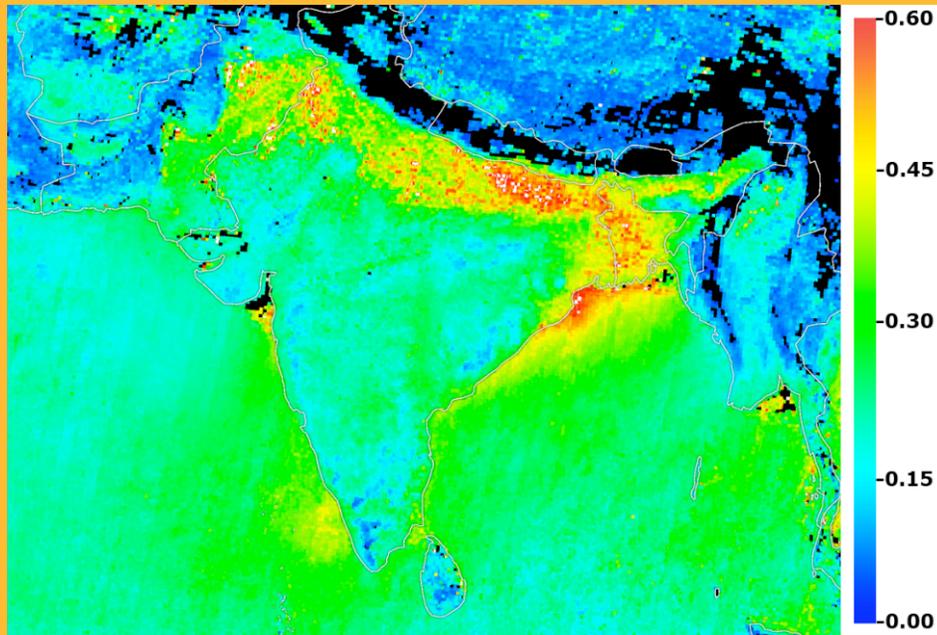
Eight Years of Seasonally Averaged Mid-visible Aerosol Optical Depth from MISR



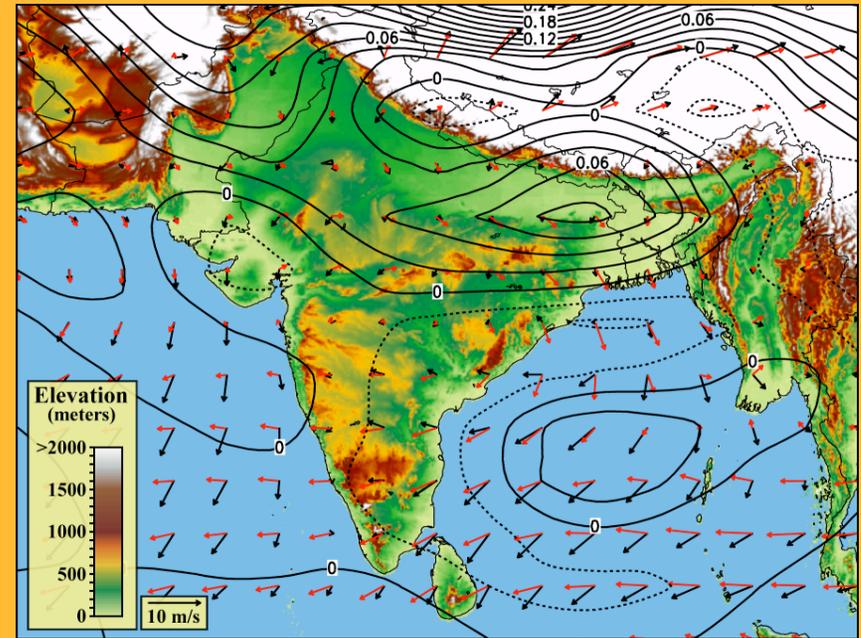
...includes bright desert dust source regions

MISR Team, JPL and GSFC

Pollution Aerosol Concentrated in Ganges Valley near Kanpur, India



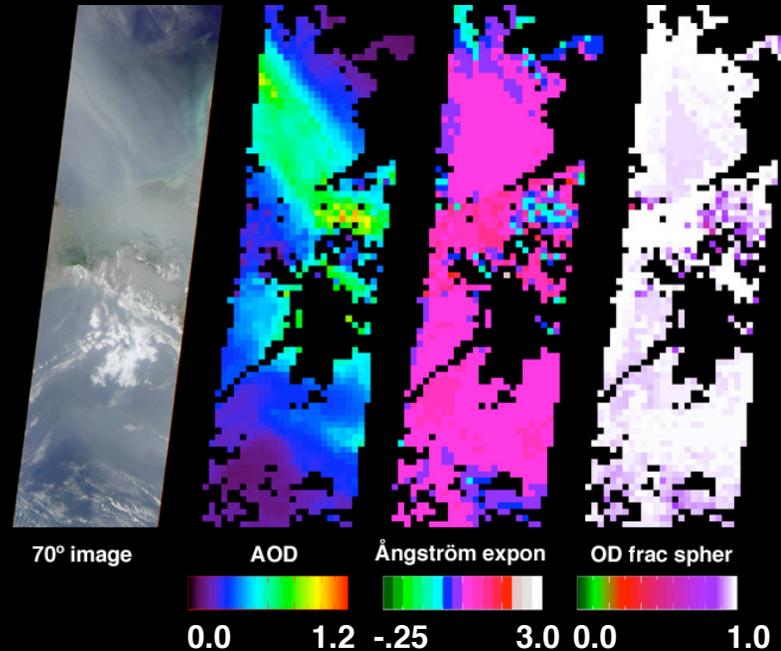
MISR mid-visible AOD
[Winter, 2001-2004; white --> AOD >0.6]



NCEP Winds + Topography
[Black=surface; Red=850 mb;
contours=vertical, solid=subsidence]

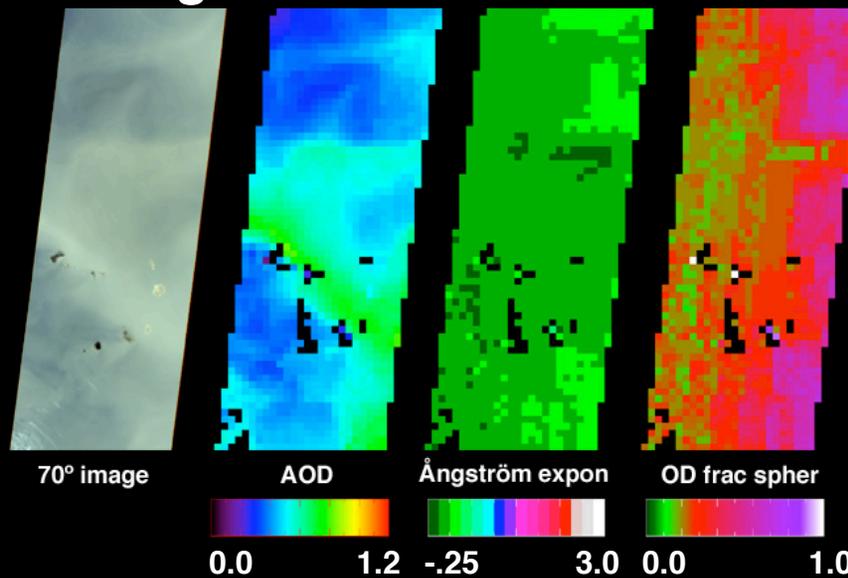
Smoke from Mexico -- 02 May 2002

From *MISR* –
Aerosol:
Amount
Size
Shape



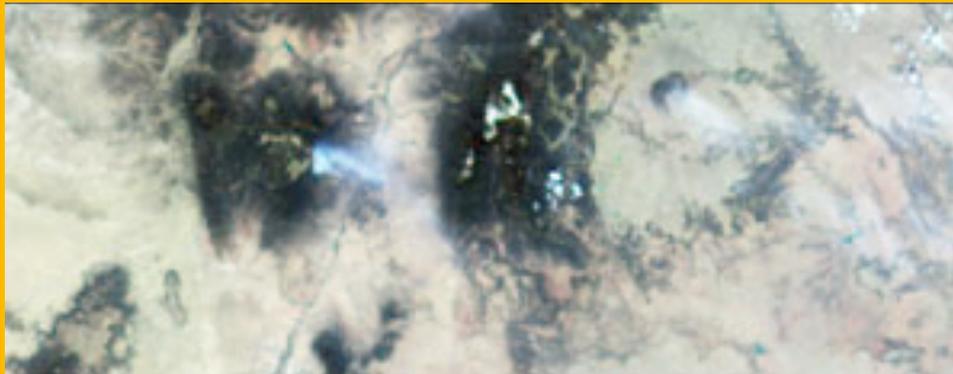
Medium
Spherical
Smoke
Particles

Dust blowing off the Sahara Desert -- 6 February 2004



Large
Non-Spherical
Dust
Particles

Los Alamos Fire, New Mexico May 9, 2000



MISR 60° Forward



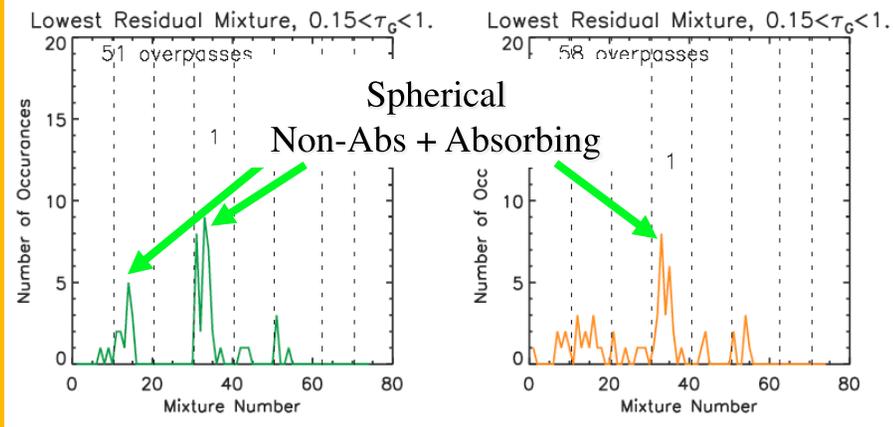
MISR Nadir



MISR 60° Aft

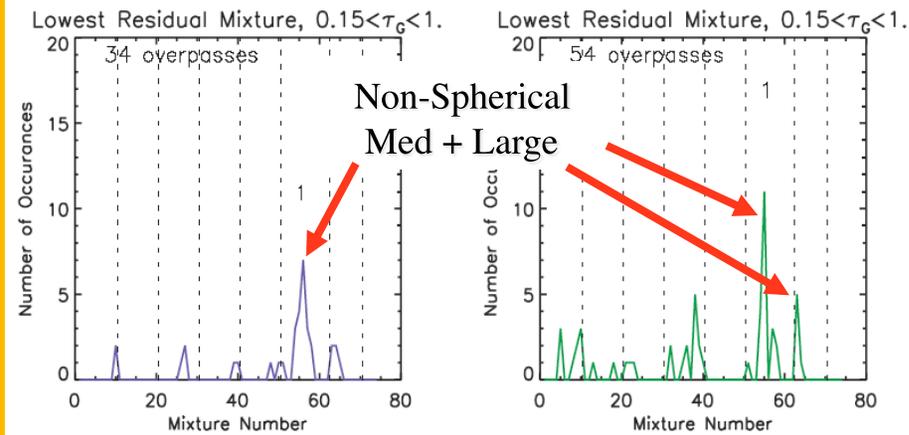
MISR-retrieved Aerosol Types

[Lowest Residual Mixtures; AOT>0.15]



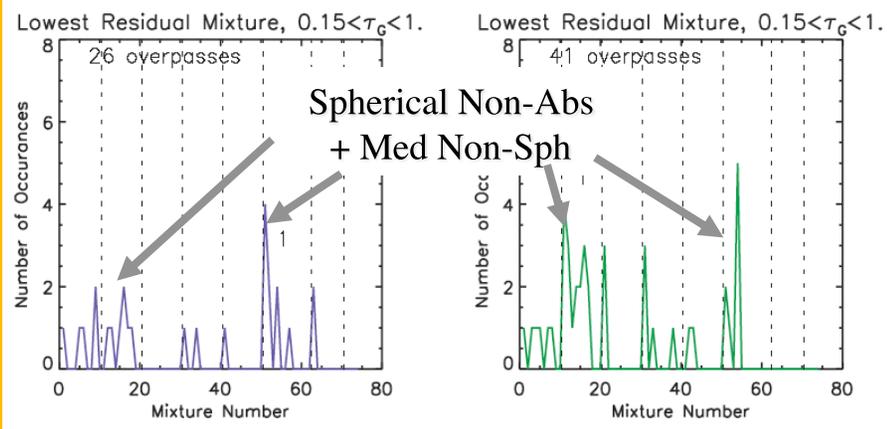
Biomss Burning

N. Summer & Autumn Events



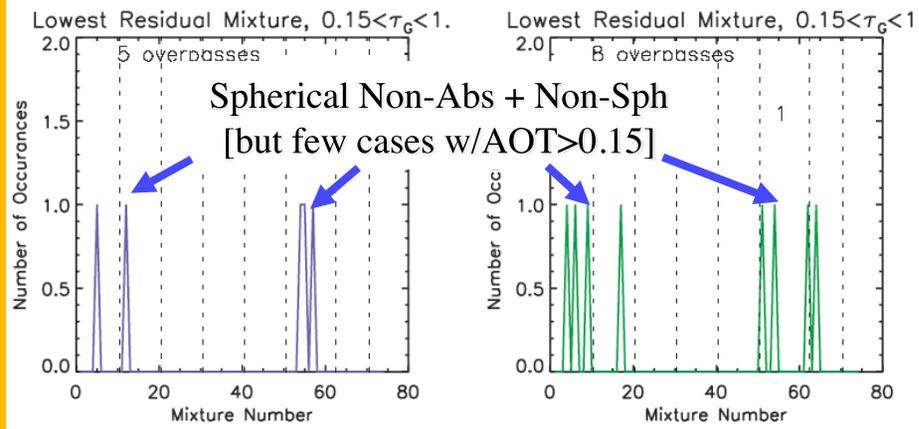
Dusty

N. Spring & Summer Events



Continental

N. Spring & Summer

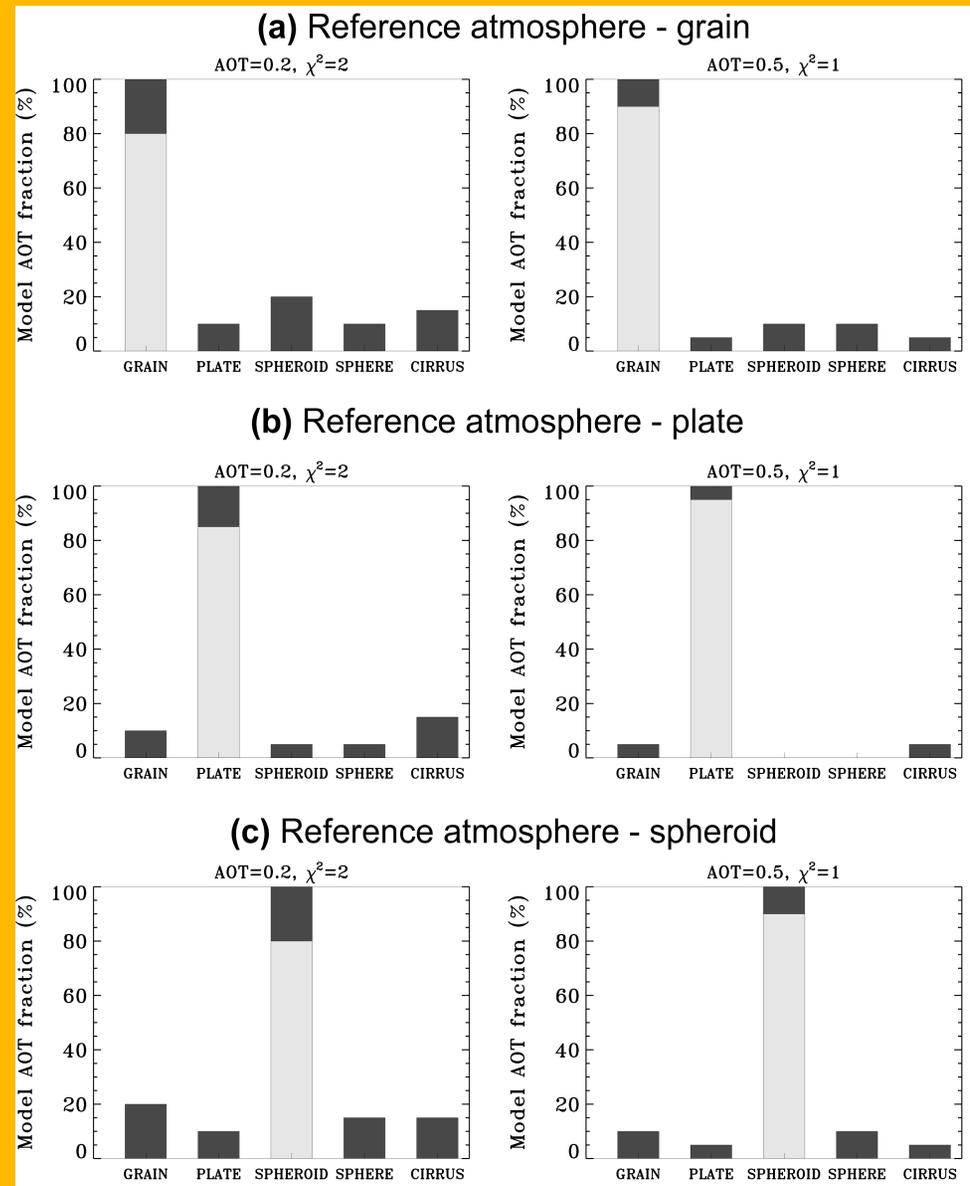


Maritime

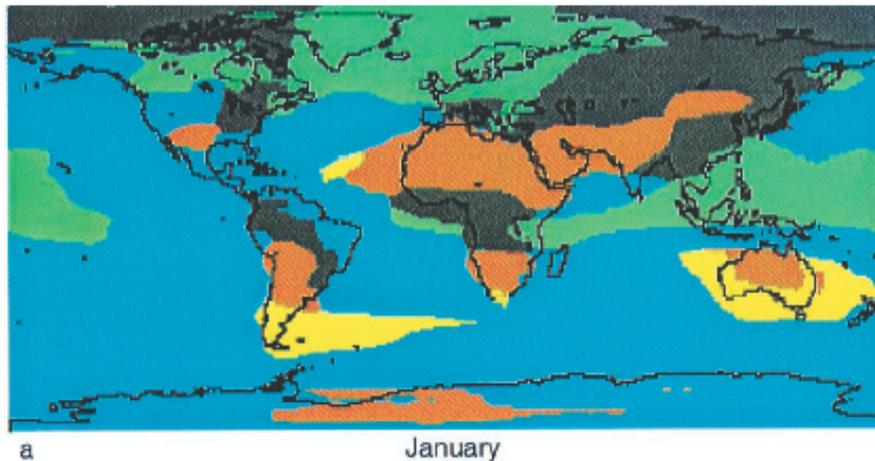
N. Spring & Summer

MISR sensitivity to Particle Shape

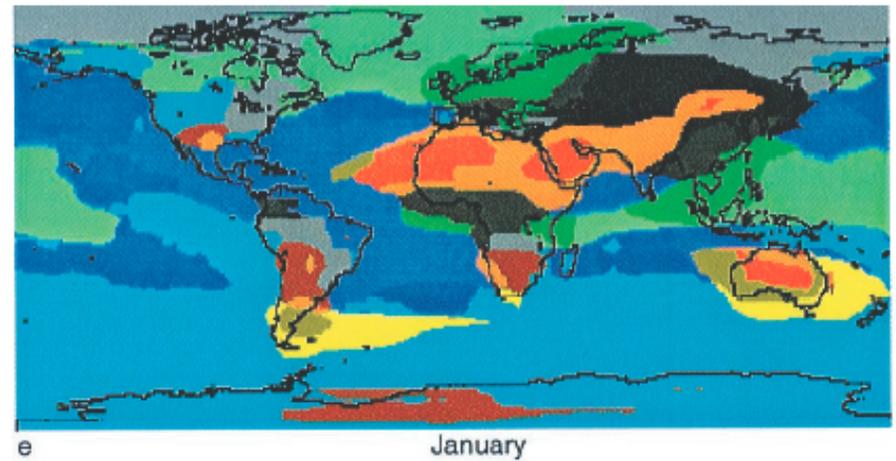
MISR can distinguish among **plate**, **grain**, **spheroidal**, and **spherical** dust model components with an uncertainty in mid-visible AOT fraction < 15-20%.



We are aiming for Regional-to-Global
Aerosol Type Discrimination something like this...



5 Groupings Based on Aerosol Properties



13 Groupings Based on Aerosol Properties

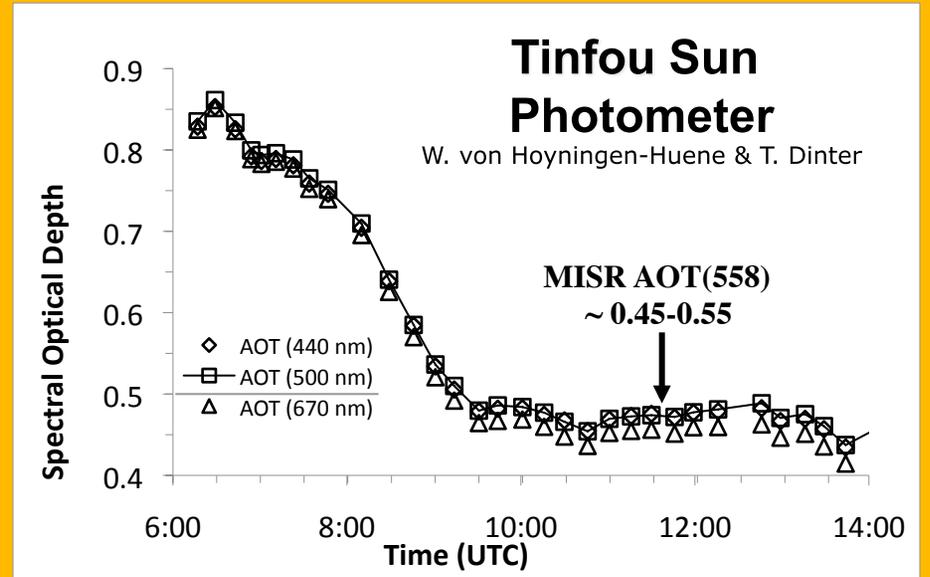
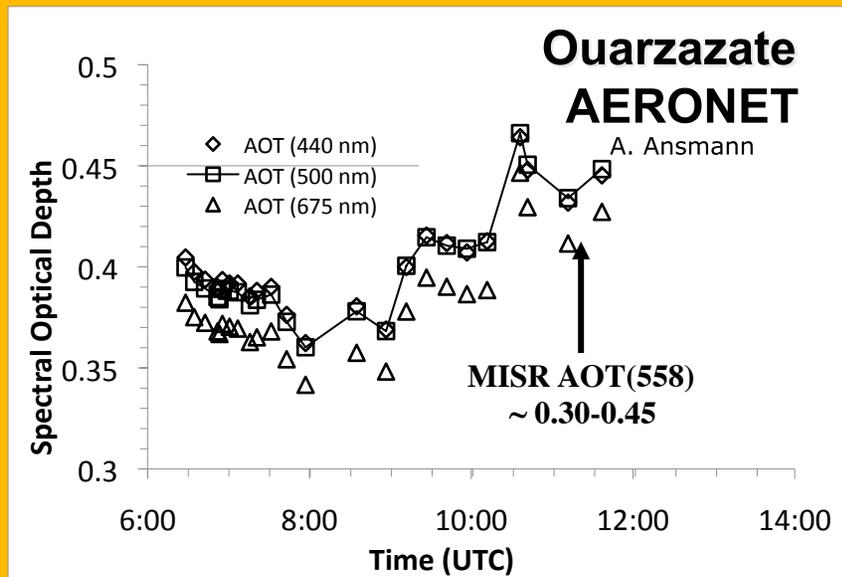
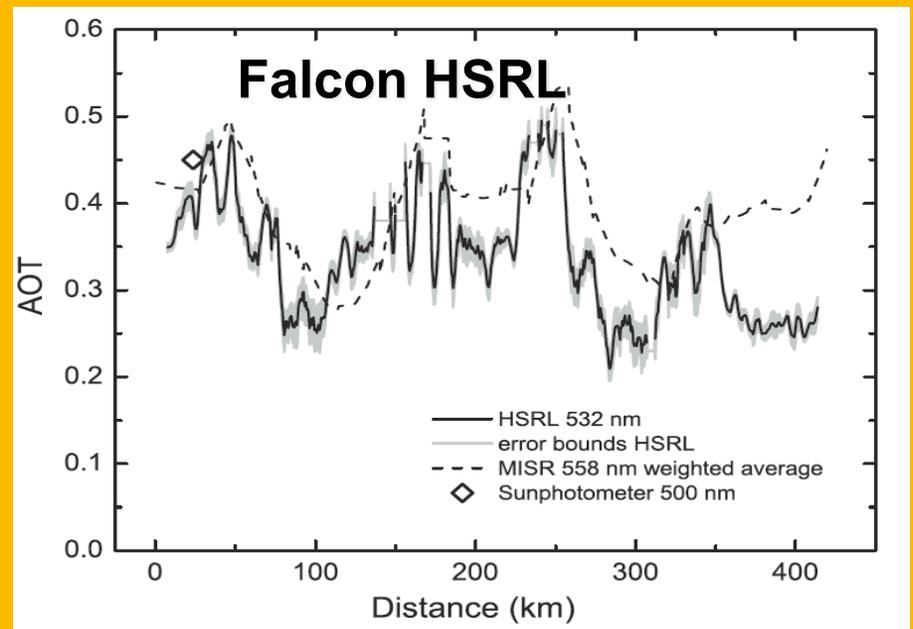
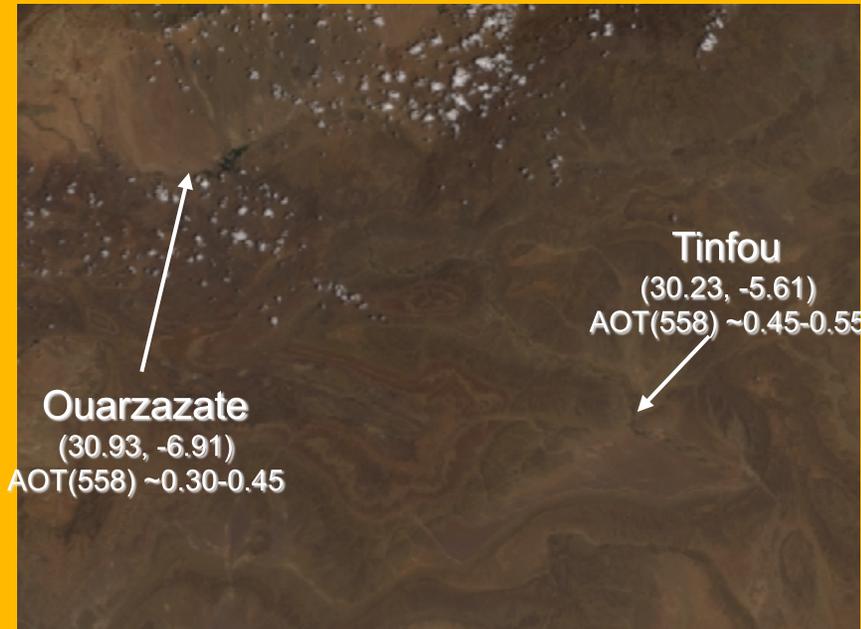
Global, Monthly Aerosol Maps Based on Expected MISR Sensitivity

The examples shown here are simulated from aerosol transport model calculations...

We currently achieve this kind of discrimination using the MISR Research Retrieval in **localized areas** [examples follow], but **not yet reliably on the global scale**.

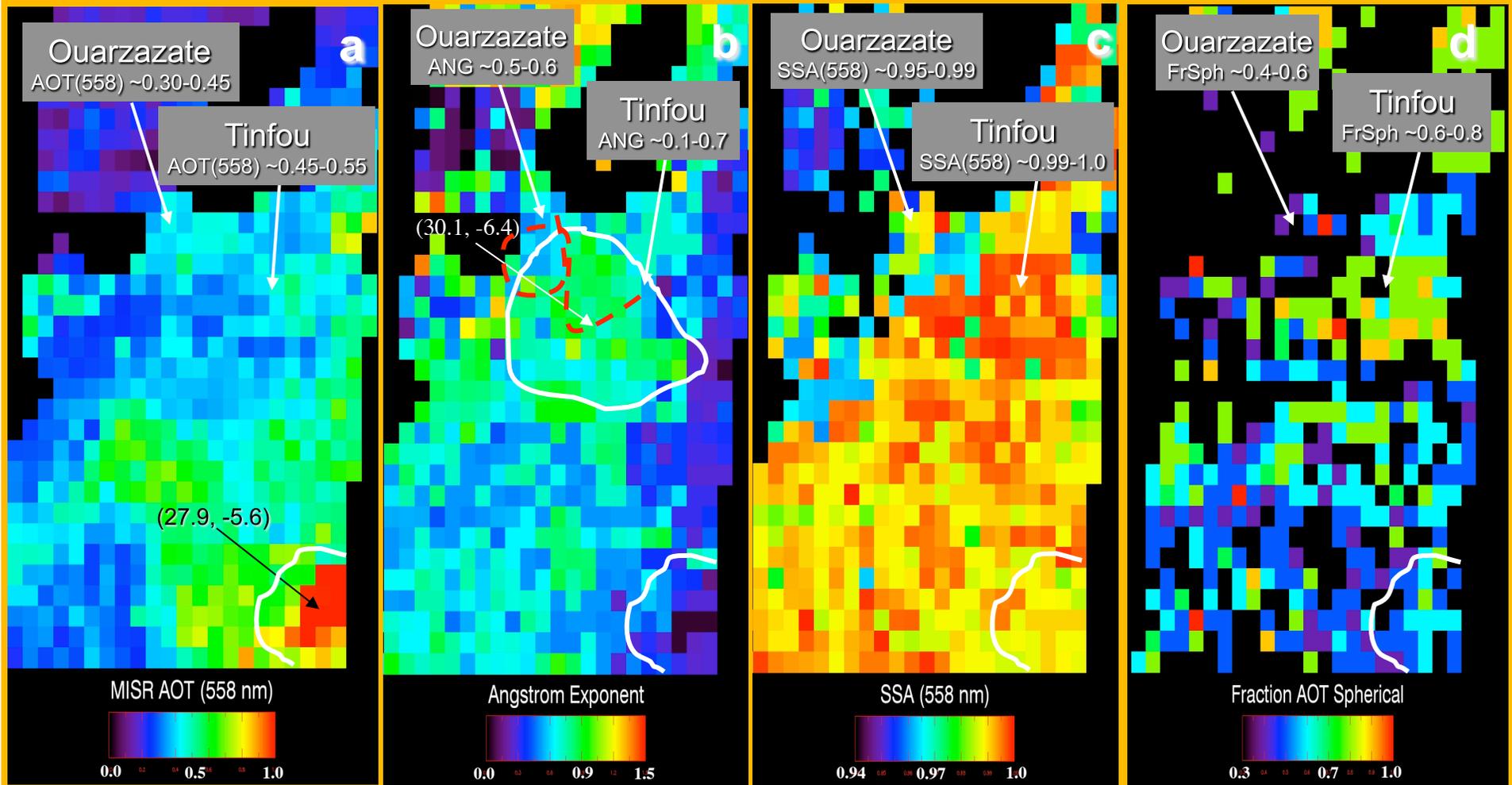
Sensitivity to particle microphysical properties varies immensely with conditions

SAMUM Campaign Morocco – June 04, 2006



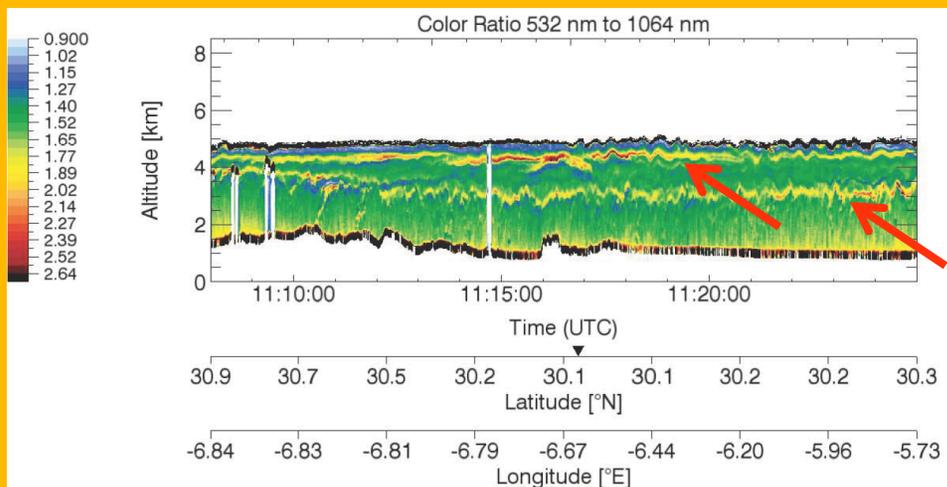
MISR SAMUM **Aerosol Air Masses (V19)** - June 04, 2006

Orbit 34369, Path 201, Blocks 65-68, 11:11 UTC



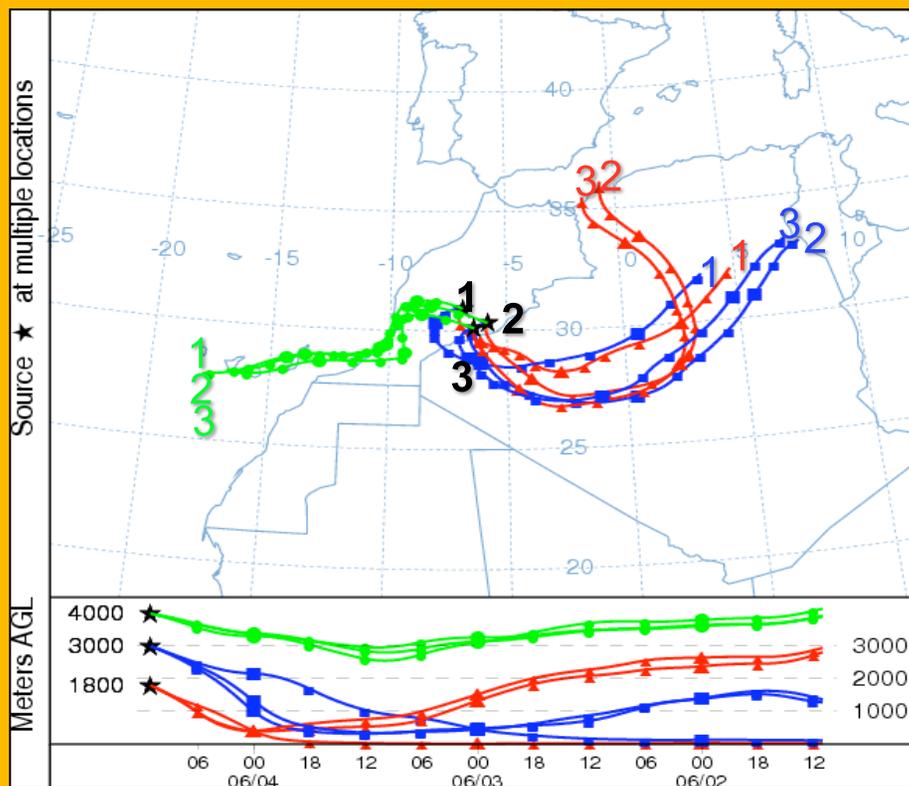
- A **dust-laden density flow in the SE** corner of the MISR swath
- **High SSA, ANG & Fraction Spherical** region SE of Ouarzazate, includes Zagora

MISR SAMUM Aerosol Air Mass Validation - June 04, 2006



Falcon F-20 HSRL

- Thin layers of small, bright particles



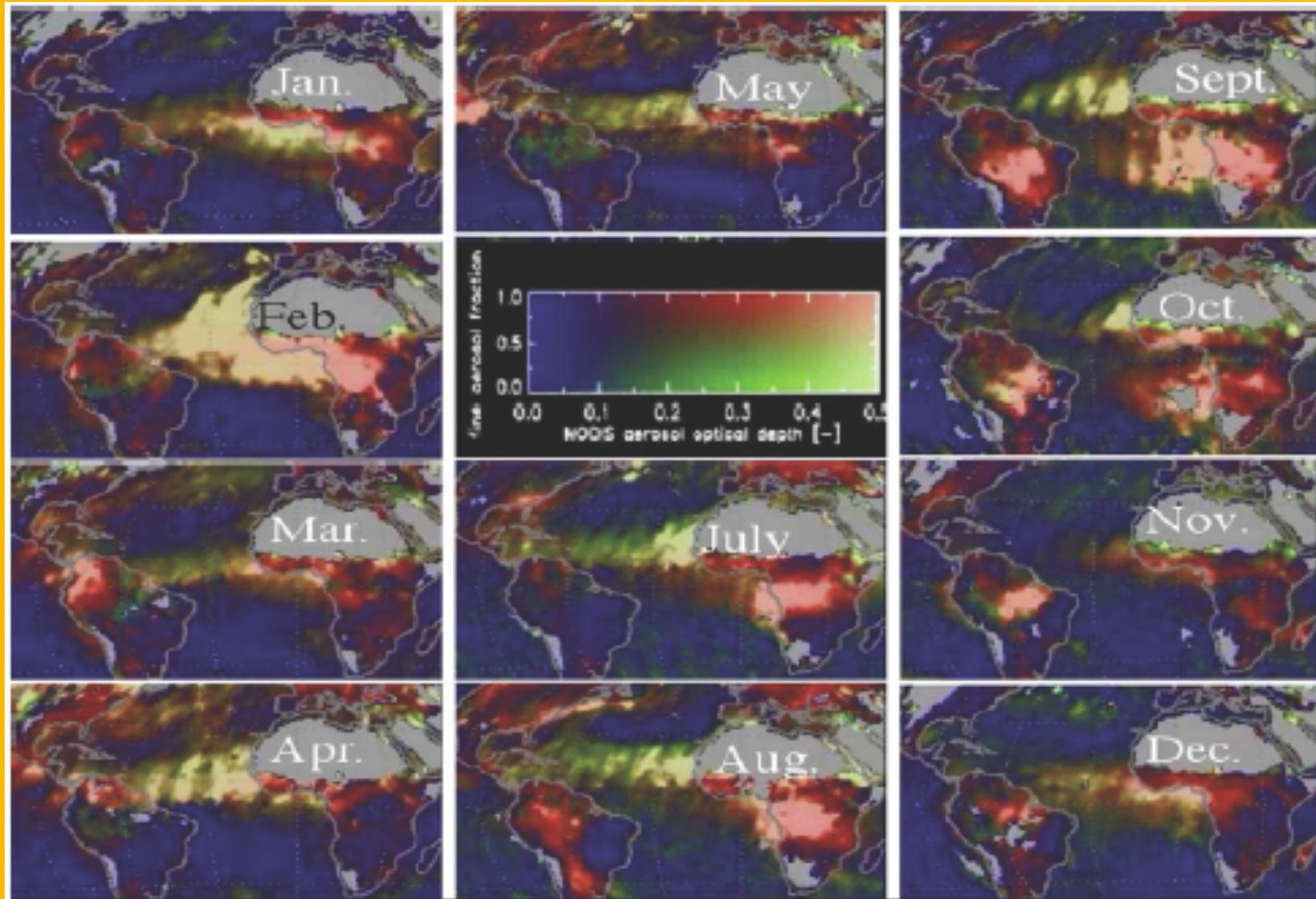
NOAA/HYSPLIT Back Trajectories

-Source in N Algeria for 2, 3 but not 1.

Kahn et al., Tellus 2008

One MODIS Aerosol Type Classification:

Low AOT (blue), **High AOT+Coarse** (green), **High AOT+Fine** (red)



Multi-angle, Multi-Spectral Information about Aerosol Microphysical Properties

Under **good but not necessarily ideal** viewing conditions:

- **Aerosol Extinction Optical Depth** (τ_a)
 - Determined to **at least 0.05 or 20%**, whichever is larger, for common aerosol types except soot, even when microphysical properties are poorly known.
- **Particle Size** (r_a)
 - **“Small,” “Medium,” and “Large”** size discrimination
Over Accumulation Mode – key for vis spectrum
- **Single-scattering albedo** (ω_0)
 - **Two to four** groups
Absorbing & non-absorbing, or “dark” and “light”
- **Spherical vs. Non-spherical** for Sahara dust indices
- **Poorer Sensitivity for $n_i > \sim 0.008$ (Black Carbon)**
 - Under good conditions, expect MISR to distinguish **about 12 aerosol air mass types** based on size, shape, and composition

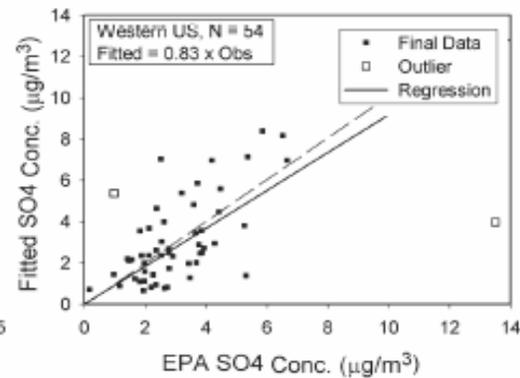
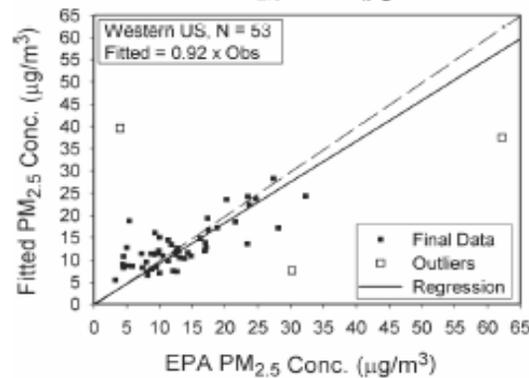
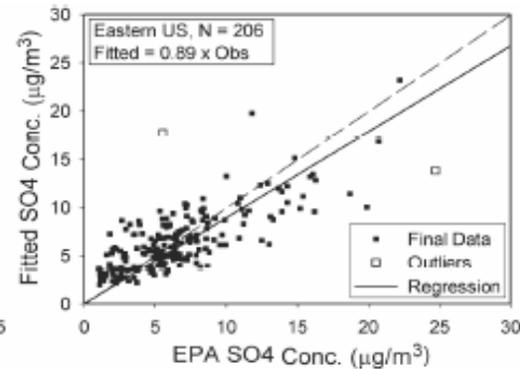
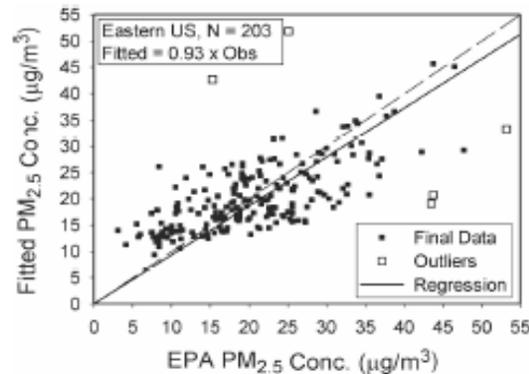
MISR - GEOS-Chem Regression Model

Aimed at Mapping **Near-surface Aerosol Pollution**

MISR-Constrained Model

PM_{2.5}

SO₄



Eastern US

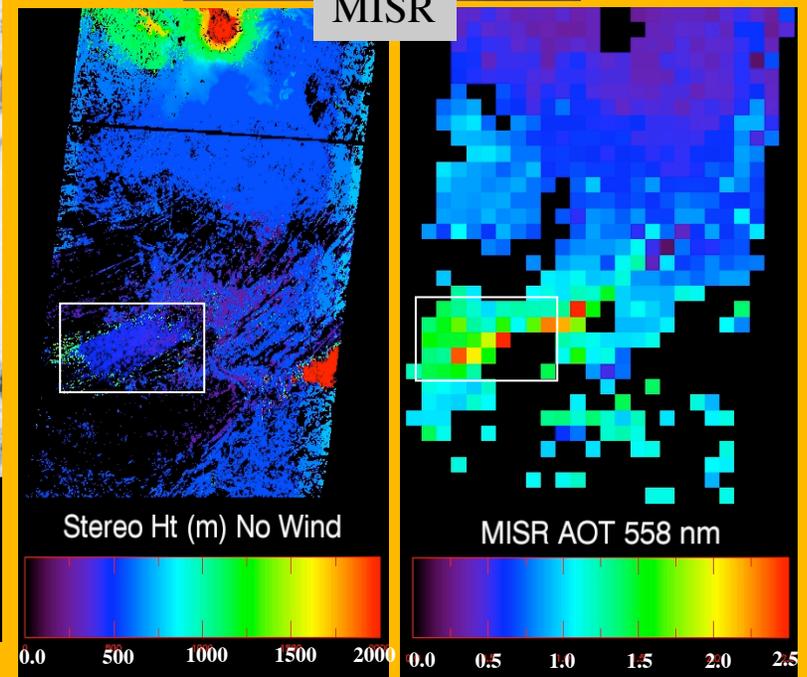
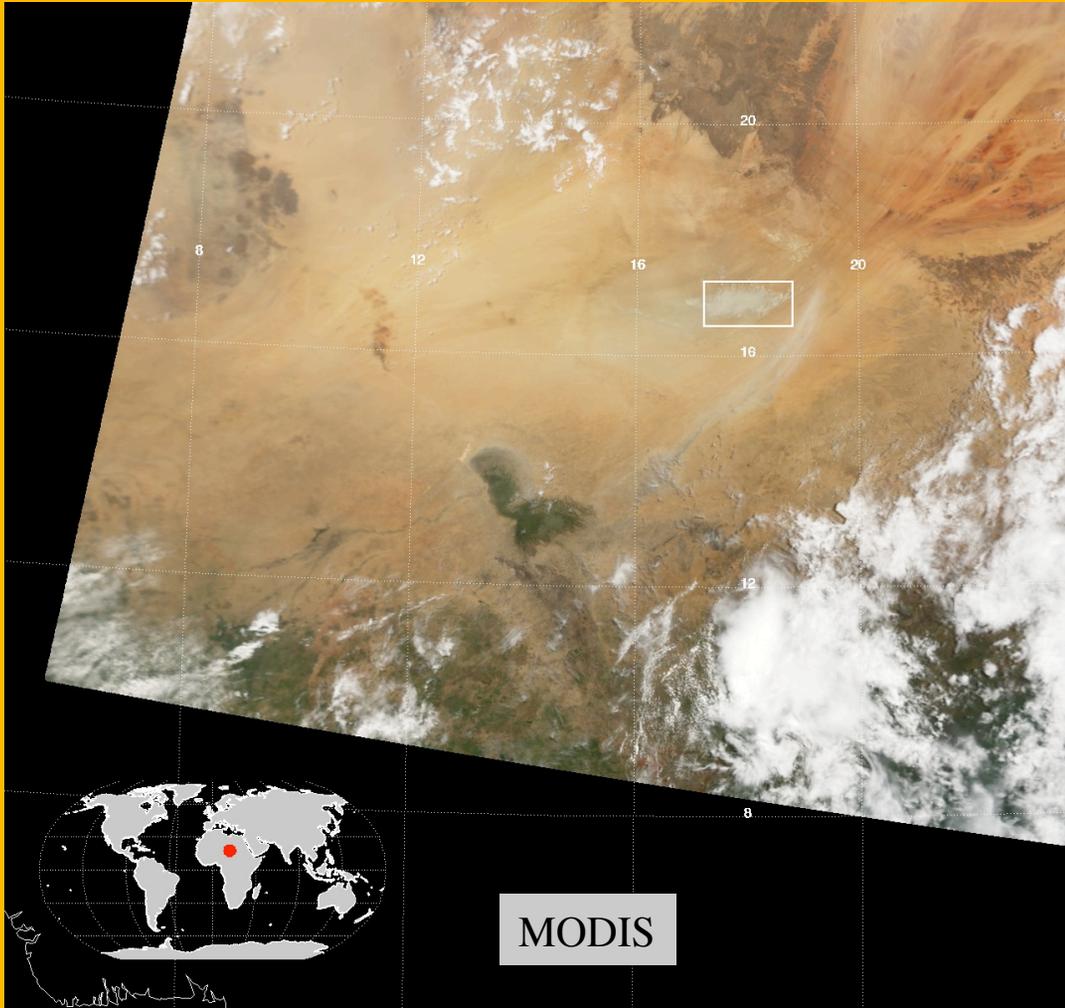
Western US

EPA Surface Measurements

- Using MISR **Particle Shape** as well as AOT to constrain model --> much better result
- Will add column Size and SSA information when MISR retrieval is more robust

Saharan Dust Source Plume

Bodele Depression Chad June 3, 2005 Orbit 29038

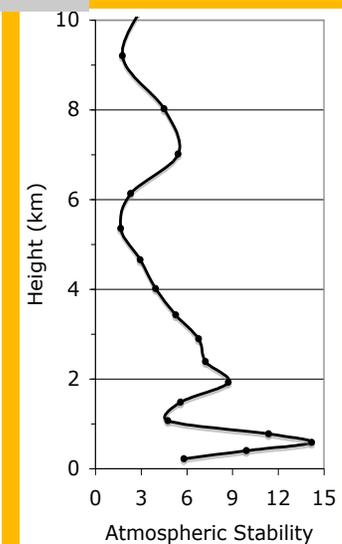
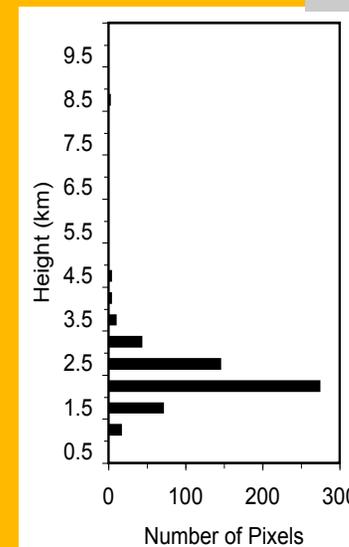
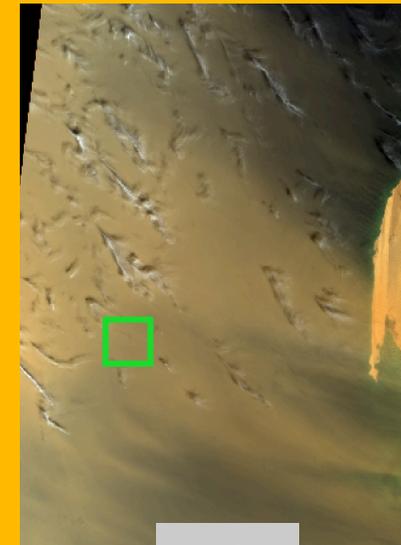
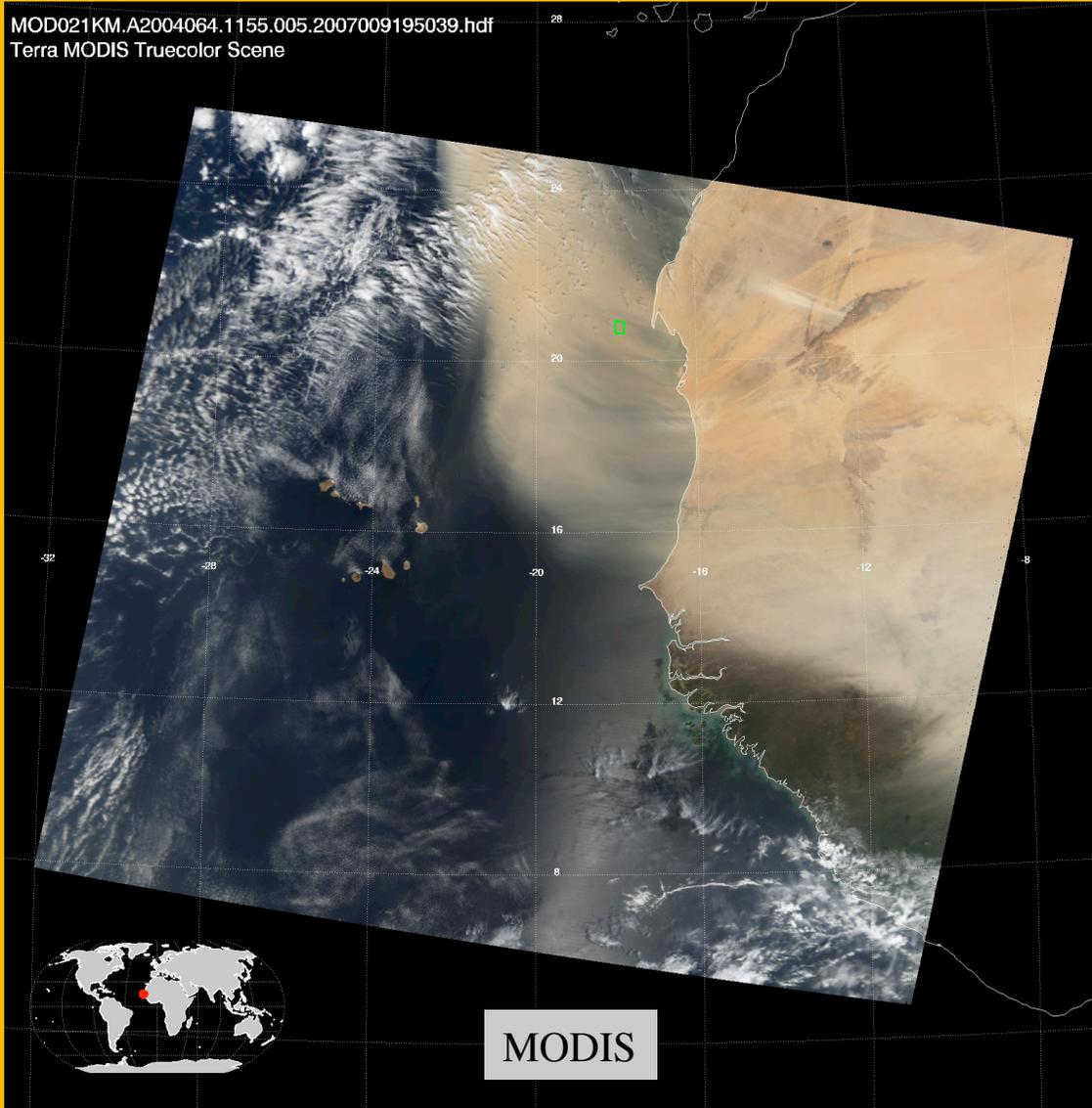


Dust is injected near-surface...

Kahn et al., JGR 2007

Transported Dust Plume

Atlantic, off Mauritania March 4, 2004 Orbit 22399

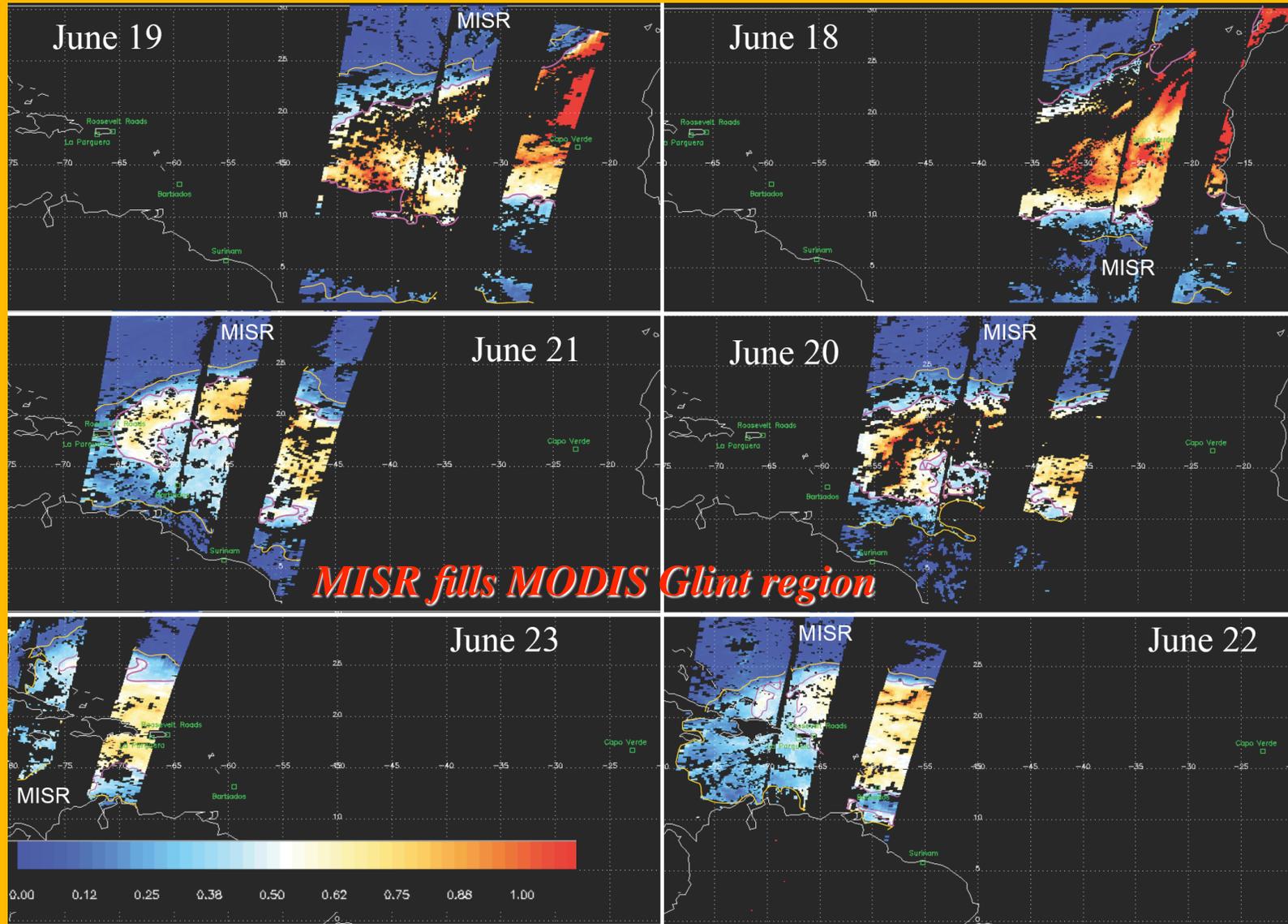


Transported dust finds elevated layer of relative stability...

Kahn et al., JGR 2007

Complementary MISR and MODIS AOT

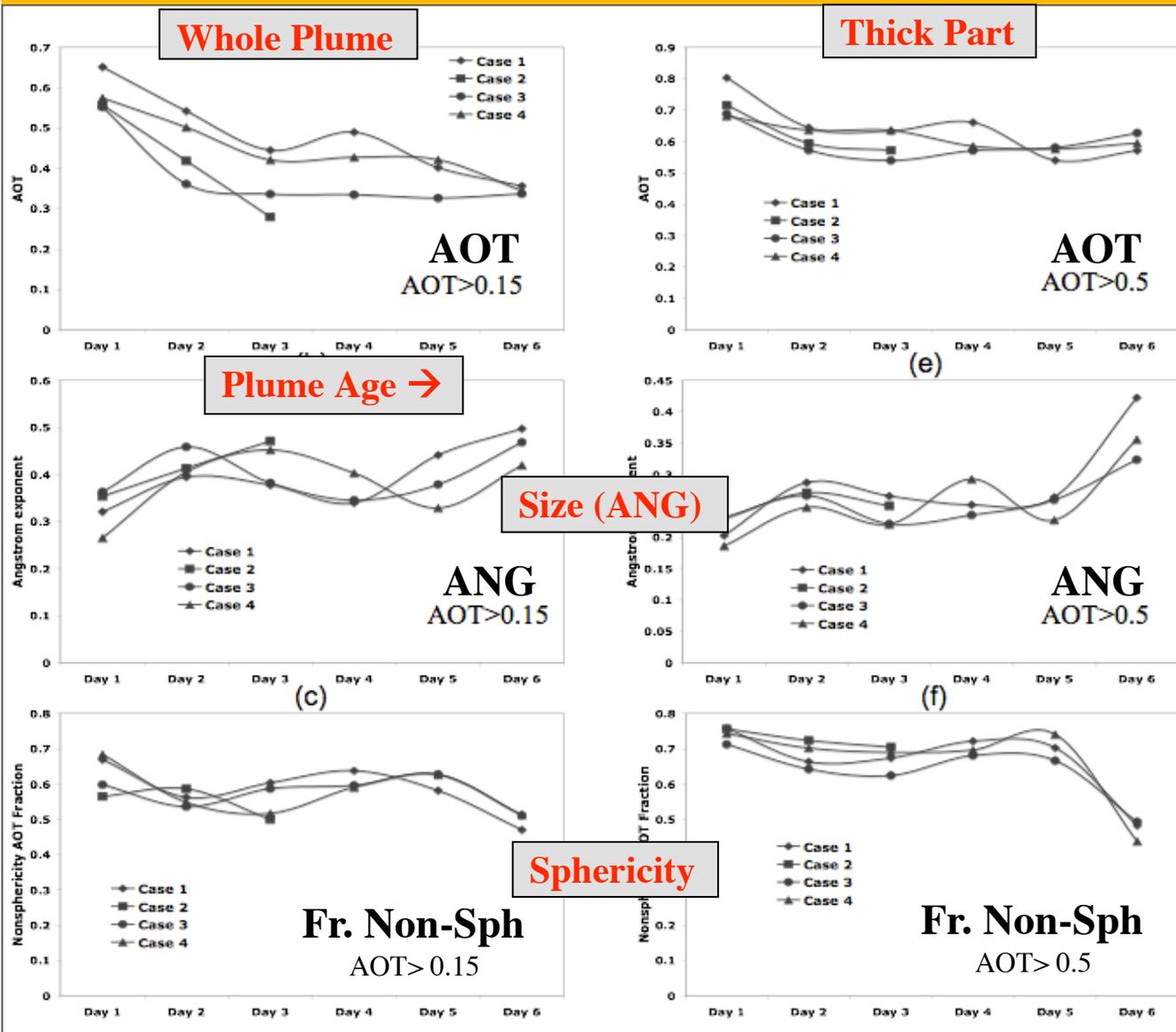
Saharan Dust Plume Transiting N Atlantic June 19-23 2000



Contours: AOT=0.15 (yellow); AOT=0.5 (purple)

Kalashnikova & Kahn JGR 2008

MISR Dust Plume Particle Property Evolution

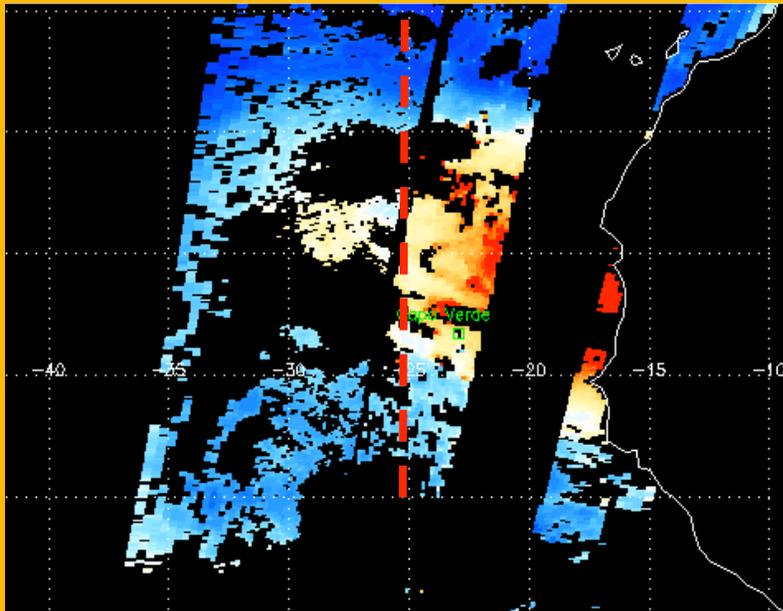


- MISR-retrieved Angstrom exponent & AOT spherical-fraction are **~30% lower** in optically thicker parts of plume, compared to total plume
- SSA ~ 0.97
- For AOT > 0.5, **Angstrom exponent increases ~30%**, and **AOT non-spherical fraction decreases** over 50%

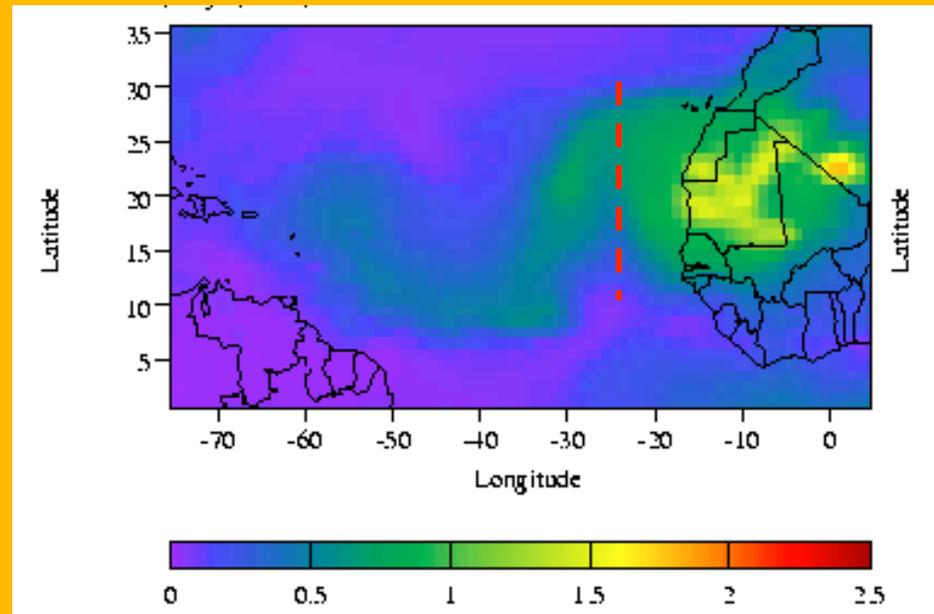
Non-monotonic behavior of MISR retrieved-properties is due to gaps in satellite coverage, since parts of the plume were not imaged on all days

MISR-MODIS-NAAPS

Aerosol Transport Model Validation July 4, 2000



MISR and MODIS AOD



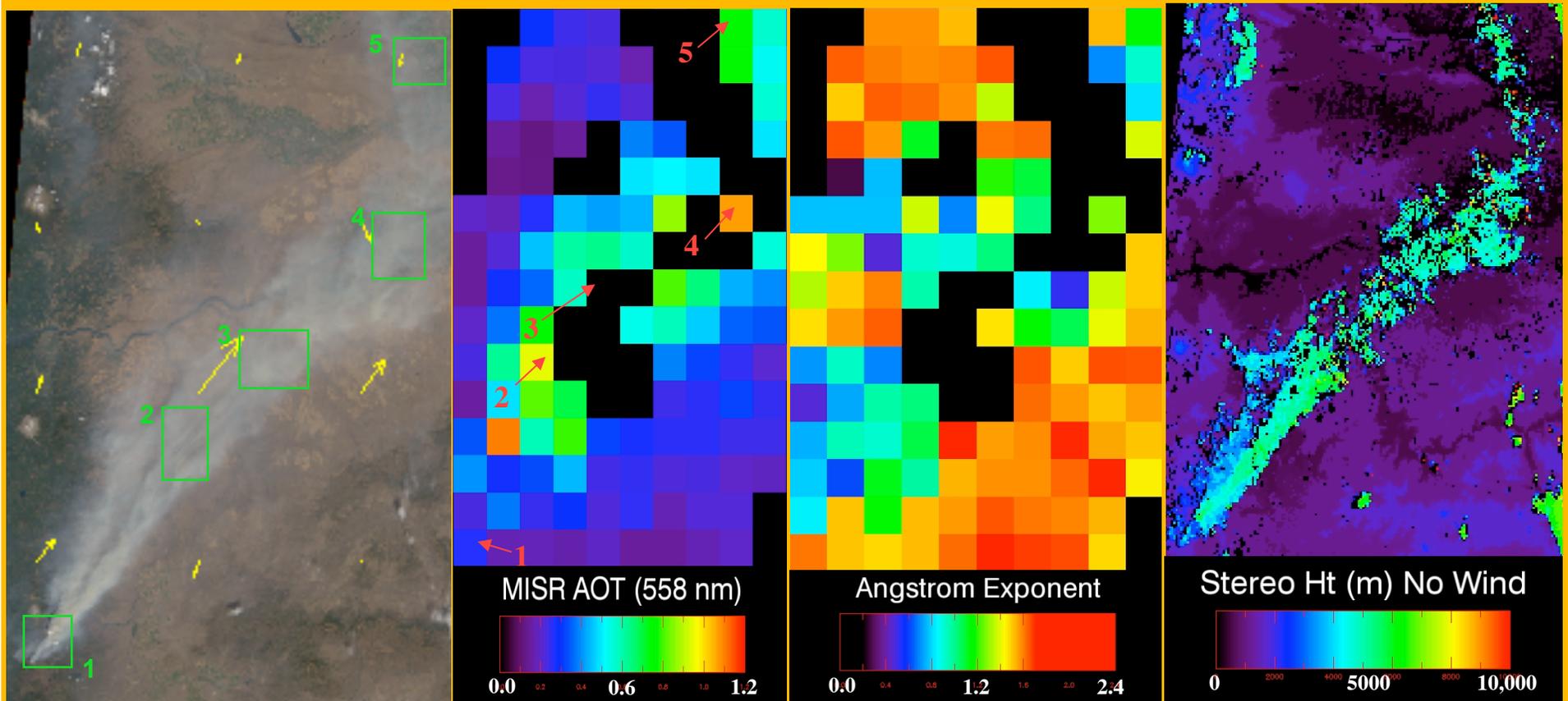
NAAPS Model Dust

NAAPS dust **plume extent** predictions:

- In **qualitative agreement** with MISR & MODIS
- Magnitudes differ... initial model sources & removal rates too strong

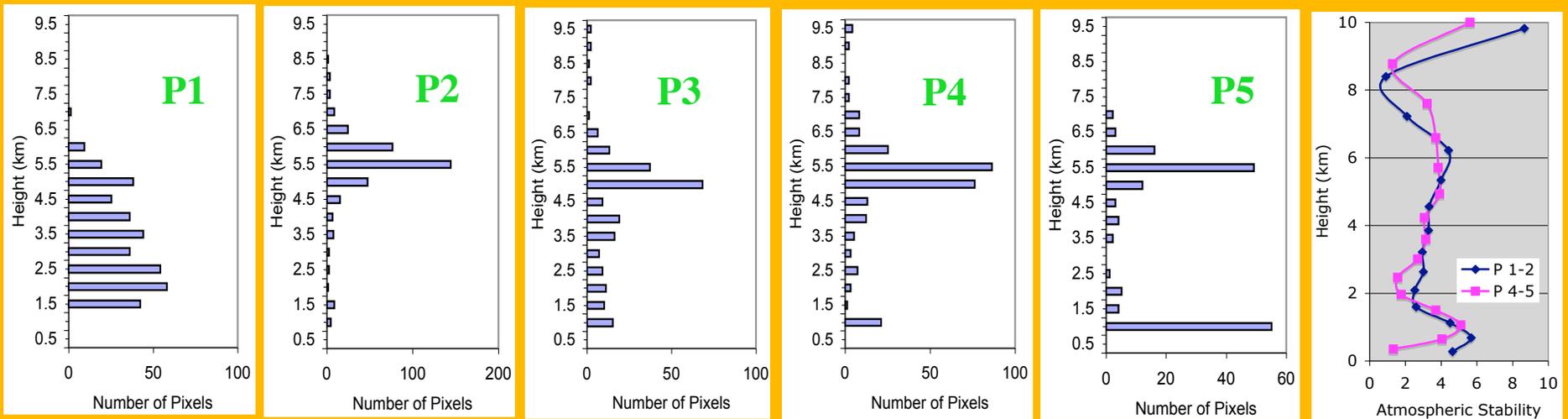
Oregon Fire Sept 04 2003

Orbit 19753 Blks 53-55 MISR Aerosols V17, Heights V13 (no winds)



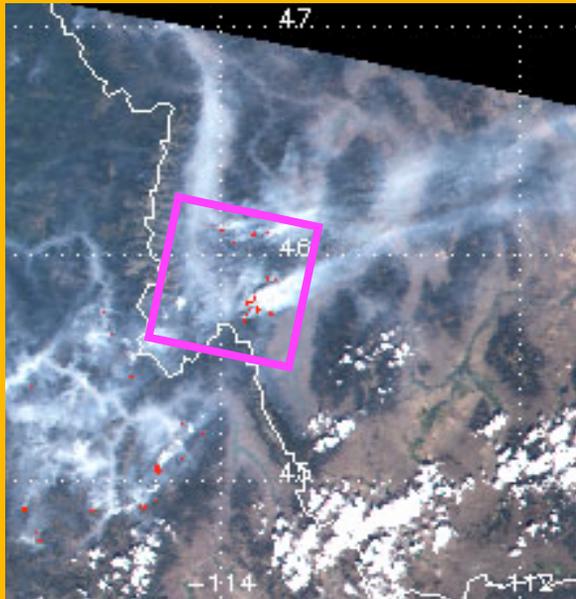
Oregon Fire Sept 04 2003

Orbit 19753 MISR Stereo Heights V13 (no winds)

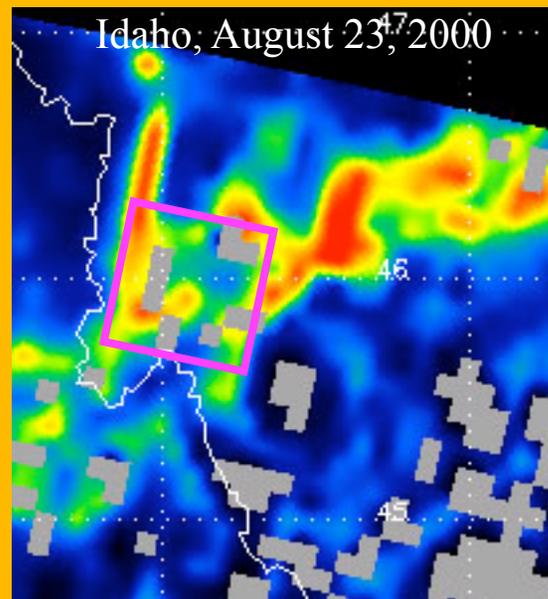


Atmospheric stability derived from NCEP re-analysis

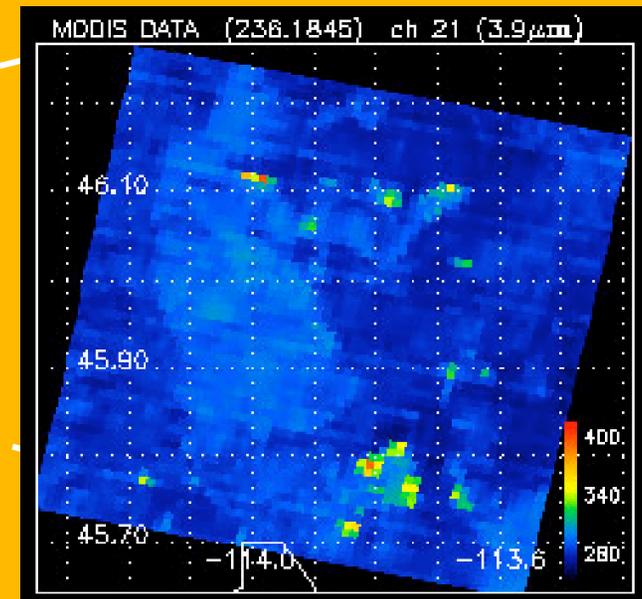
MODIS Fire Radiant Energy Flux



TOA Reflectance (RGB)



Mid-visible AOT

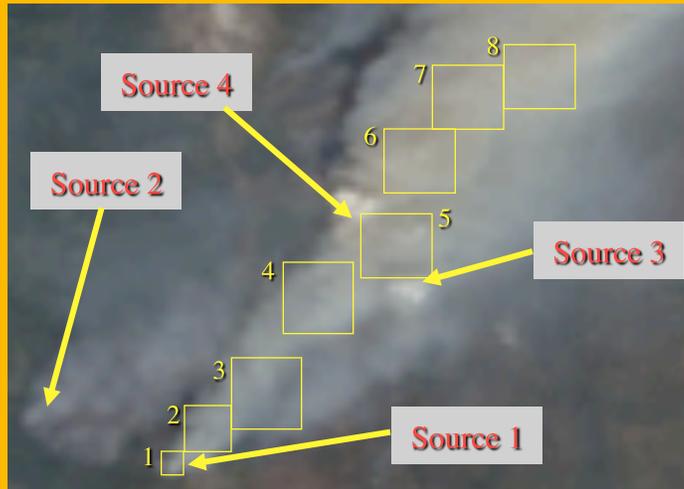


3.9 μm Fire Temperature

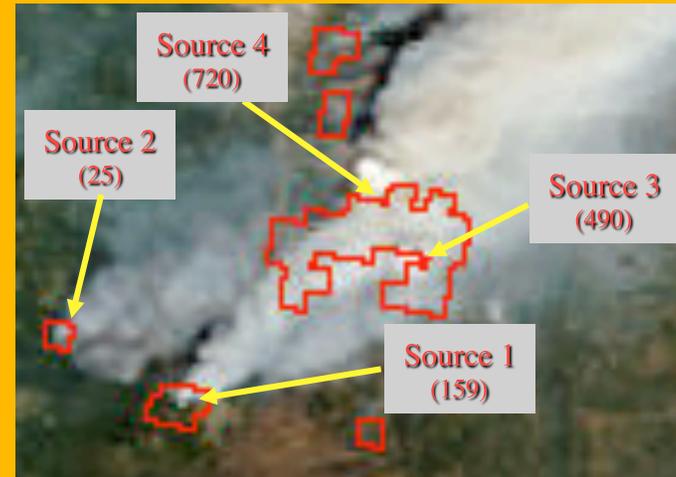
- MODIS observes **AOT** at ~10:30 am/pm and 1:30 am/pm local time
- Also **Fire Brightness Temperature** (even through smoke) --> fire radiative energy --> related to rate of biomass consumption
- Correlation yields **Smoke Emission Factors**, stratified by region
[kg smoke] : [MJ radiant emission]

Detail of the Source Region (Patch 1)

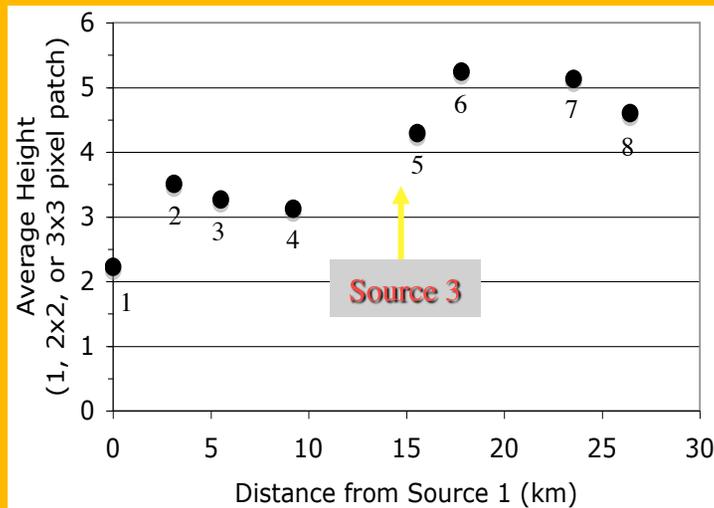
Oregon Fire Sept 04 2003



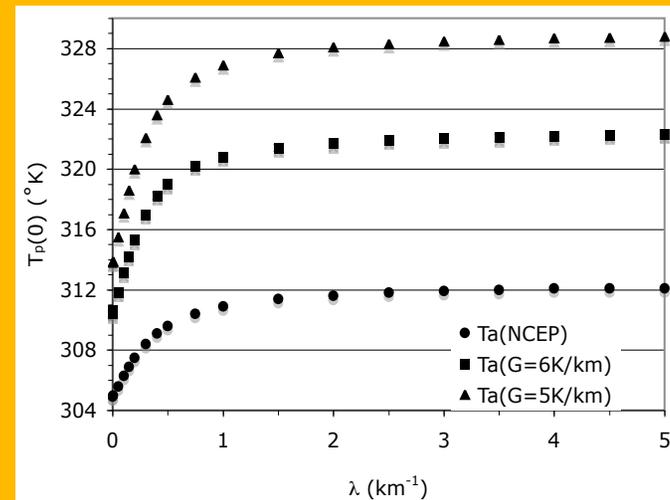
MISR Nadir 275 m Image



MODIS Image + Fire Product

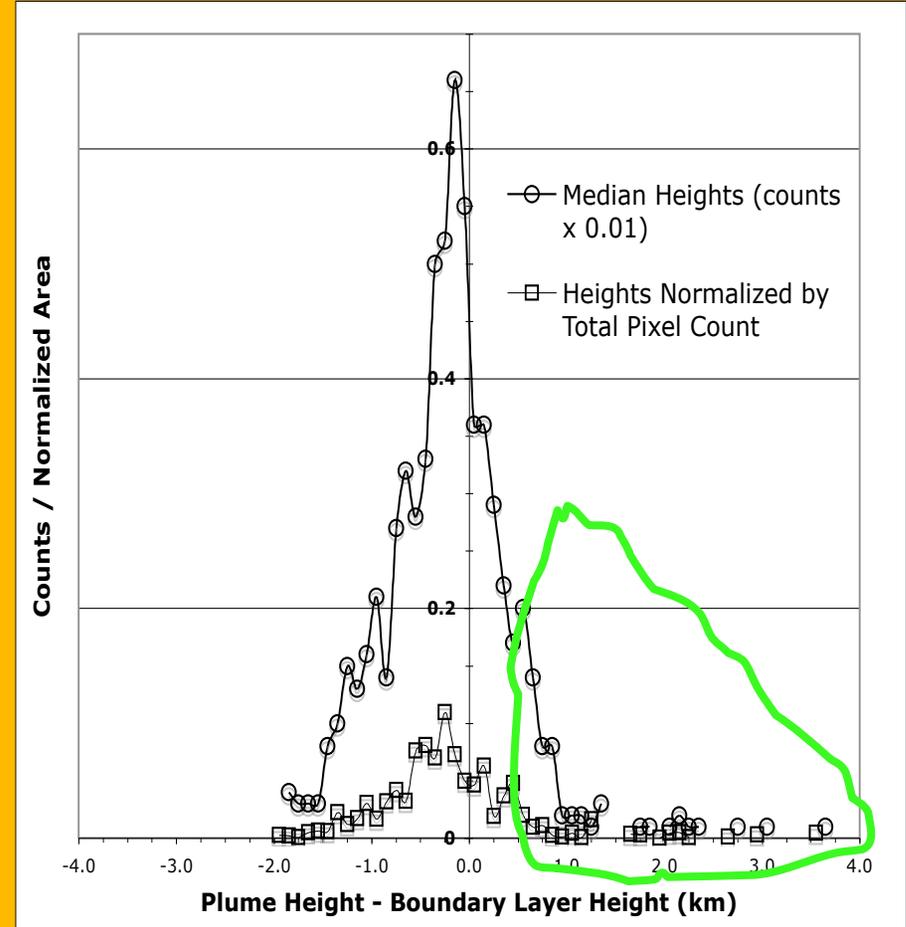
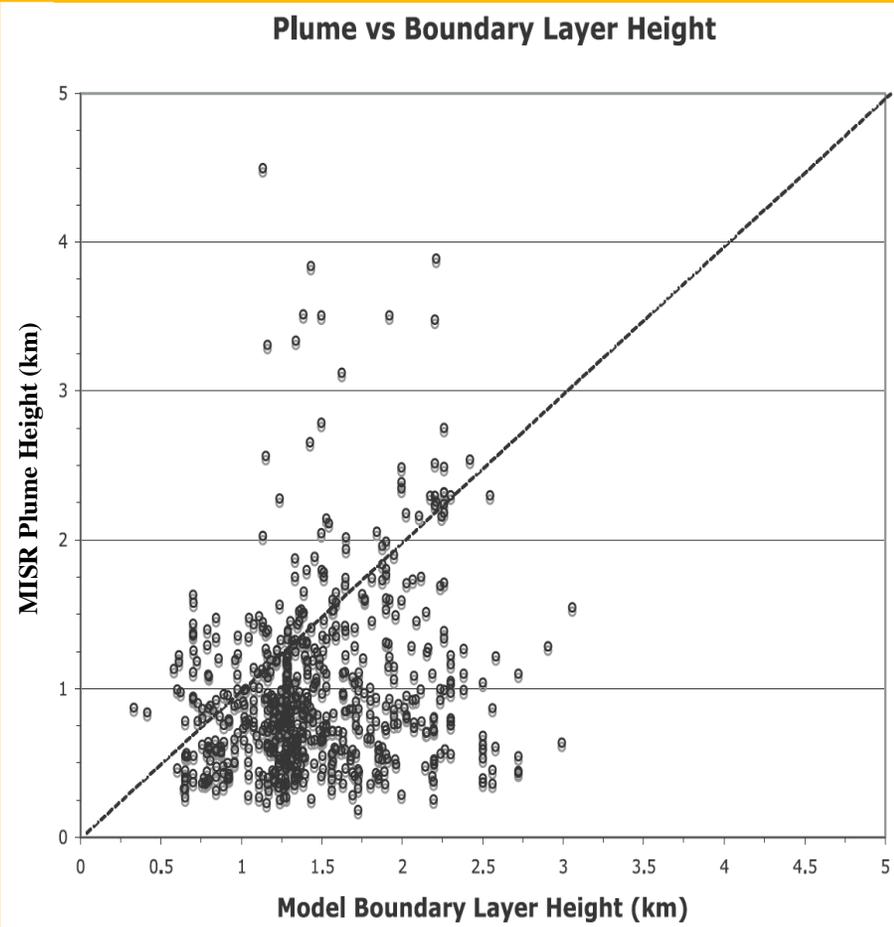


MISR Plume Heights for Patch 1 Sub-patches



Very Simple Plume Parcel Model

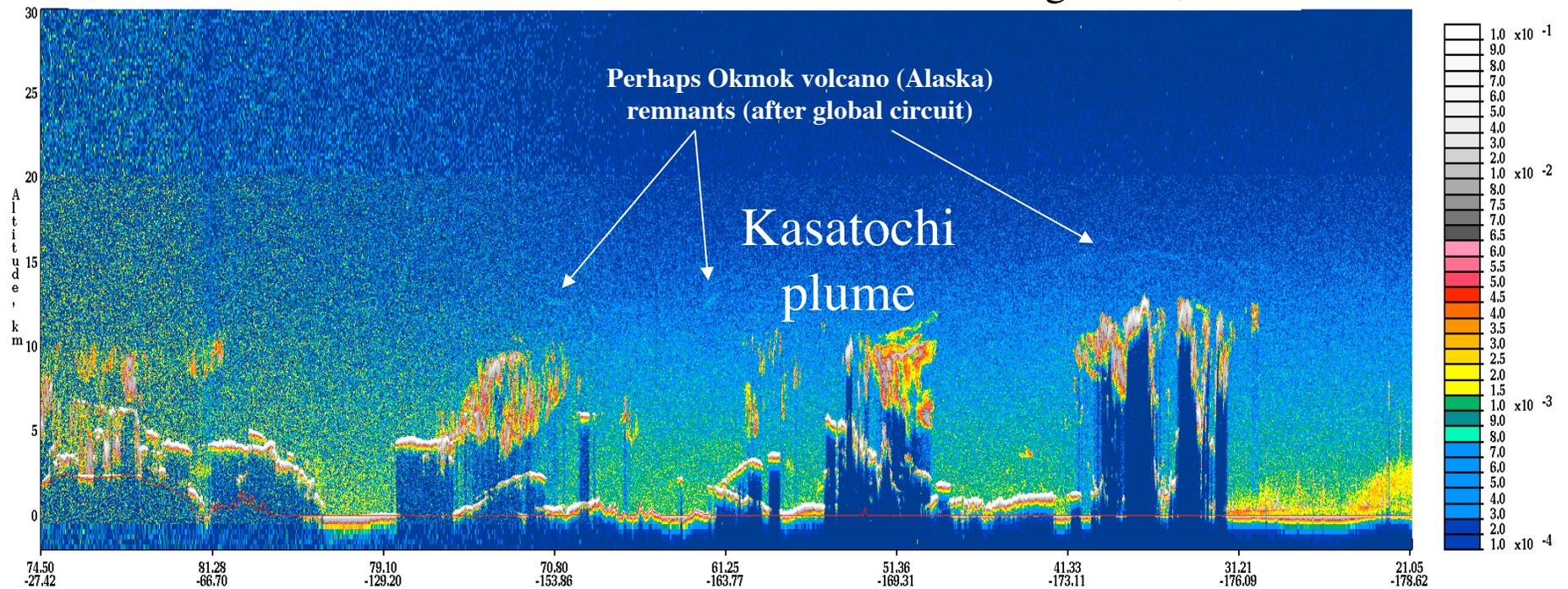
Alaska-Yukon Fire Plume Statistics, Summer 2004



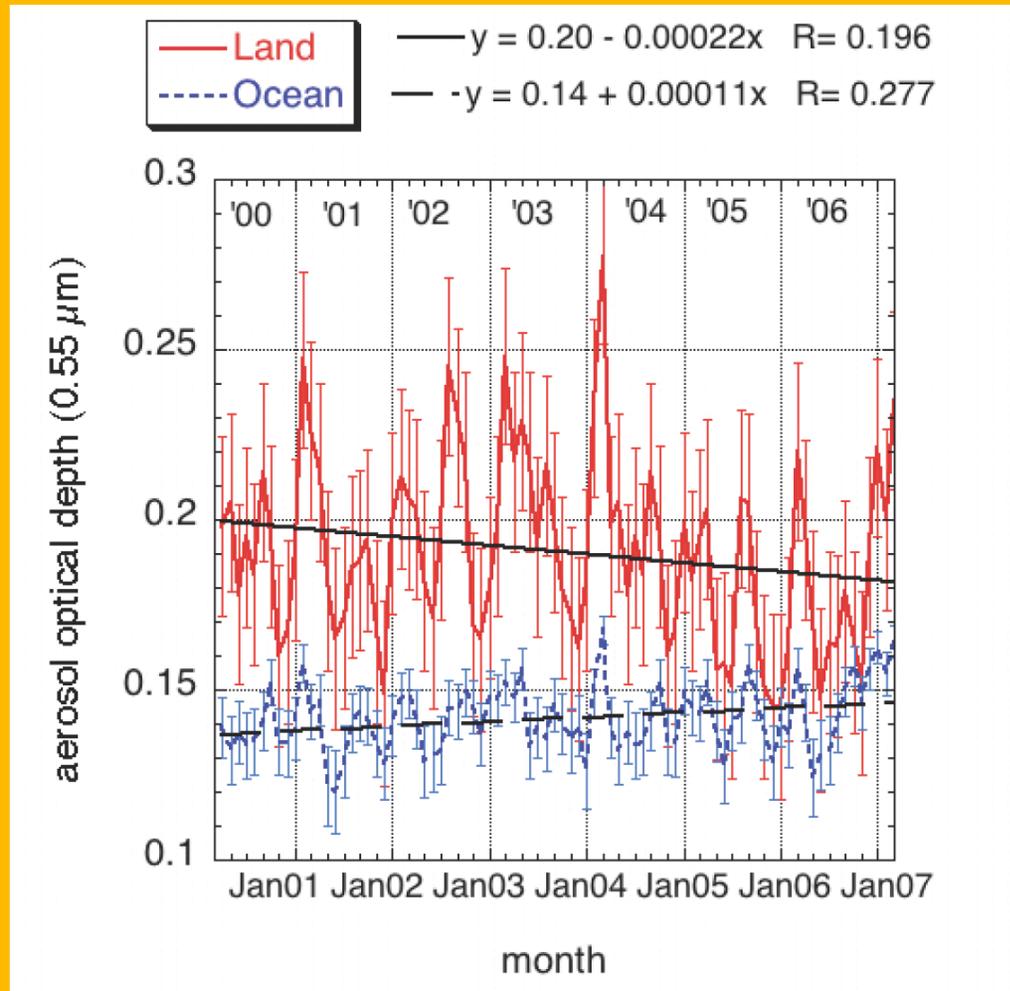
	All smoke pixel heights by Area	Median Plane heights
[Plume-ABL] Height >0	31.0%	26.2%
[Plume-ABL] Height > 0.5 km	9.5%	7.5%

Aerosol Vertical Distribution CALIPSO Space-Based LIDAR [First Light June 2006]

532 nm Total Attenuated Backscatter/km August 08, 2008

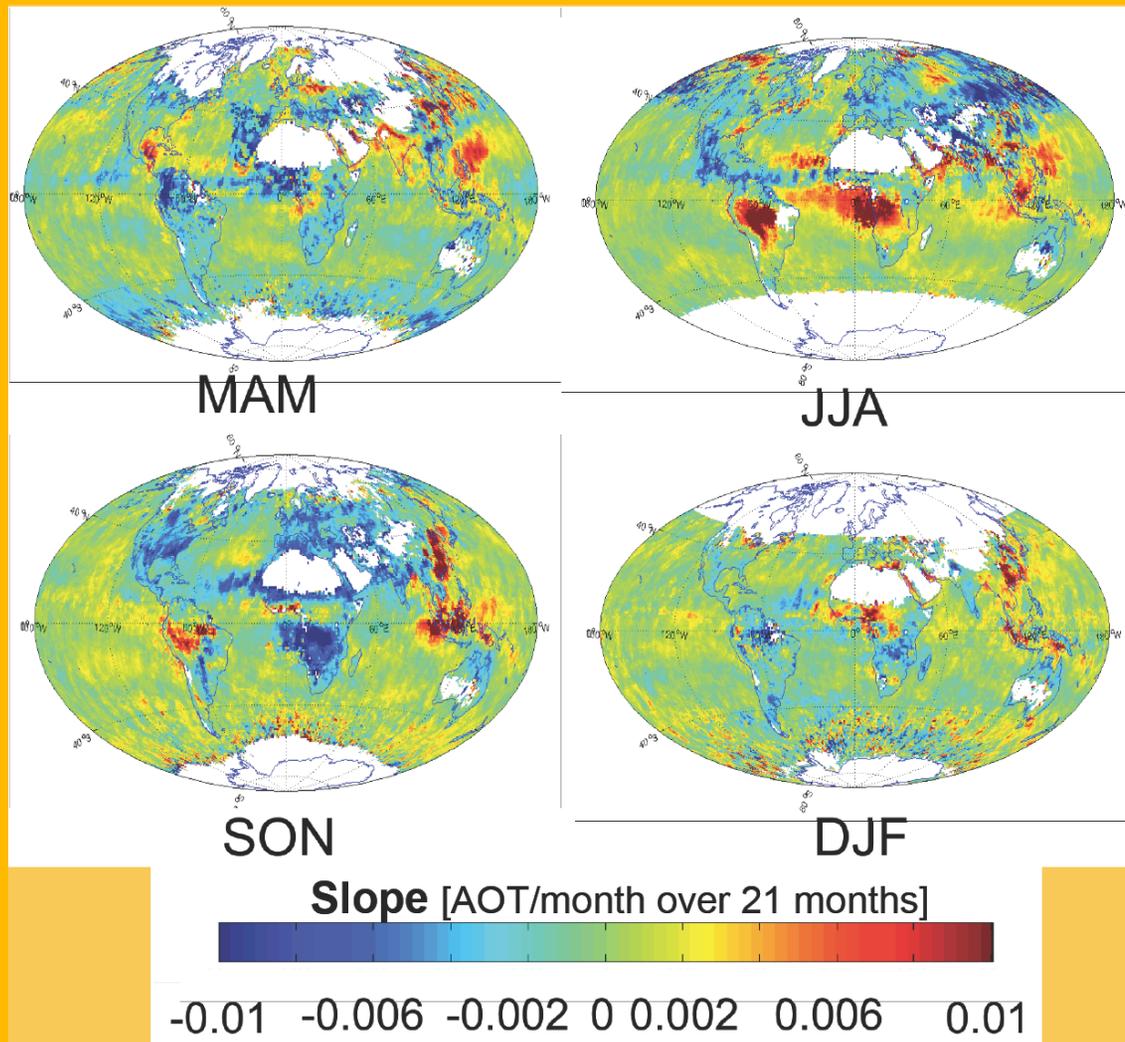


MODIS/Terra 7-Year AOD Land & Ocean Trends



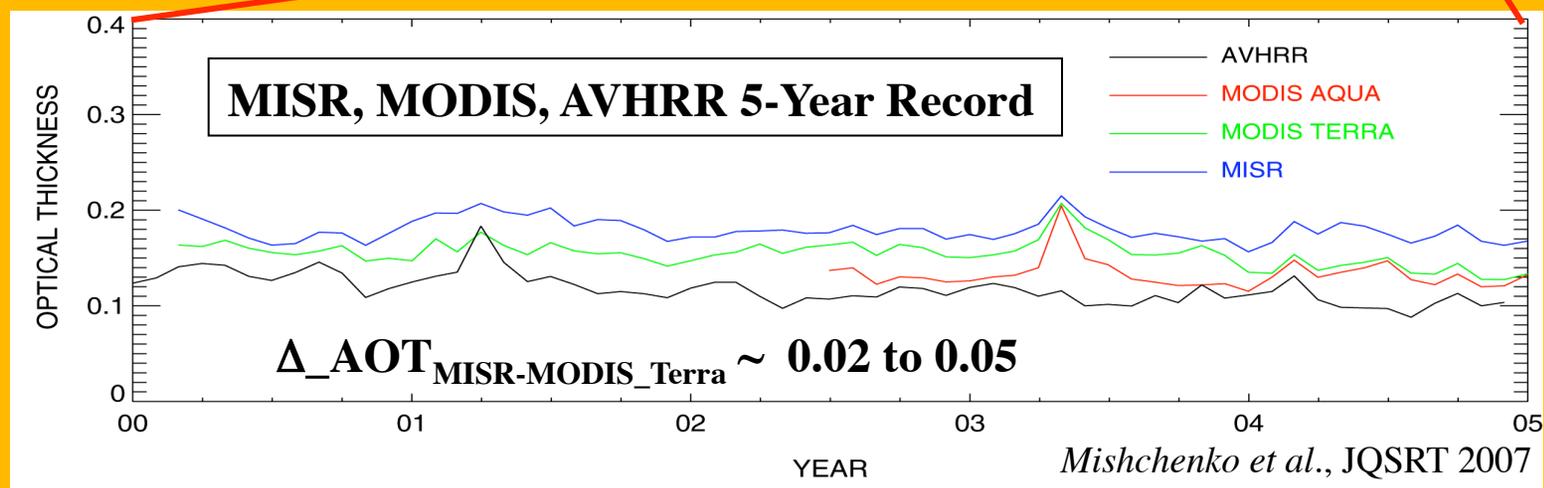
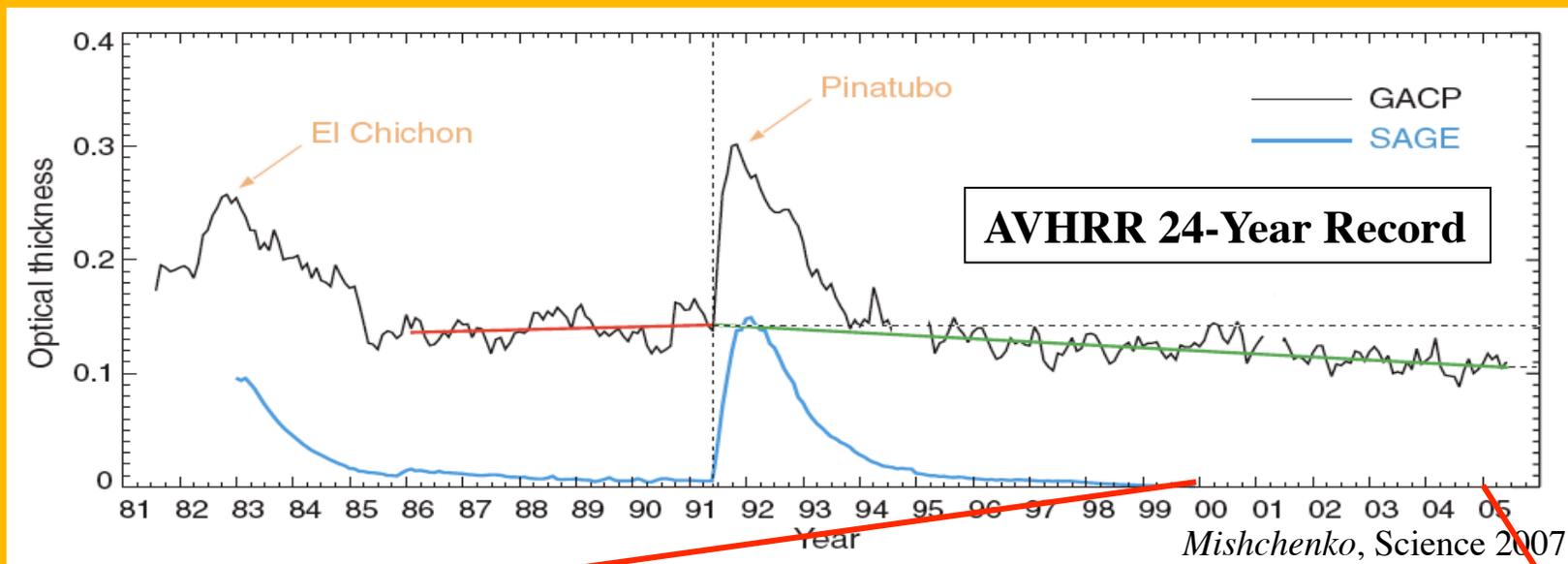
- Pixel-weighted, aggregated monthly from the $1^\circ \times 1^\circ$ Level 3 product
- Ocean AOD **increased** $+0.009$ (7%) over seven years
[significant at the 95% confidence level]
- MODIS/Aqua - Similar ocean AOD trend, **but offset by ~ -0.12**

MODIS/Terra 7-Year Regional/Seasonal AOD Trends



- **Decrease over land, *except* E Asia** + tropical Africa, S America, Indonesia **burning** seasons
- **Increase over ocean**, especially downwind of biomass burning areas

Monthly, Global-Average, Over-Ocean AOT Trends

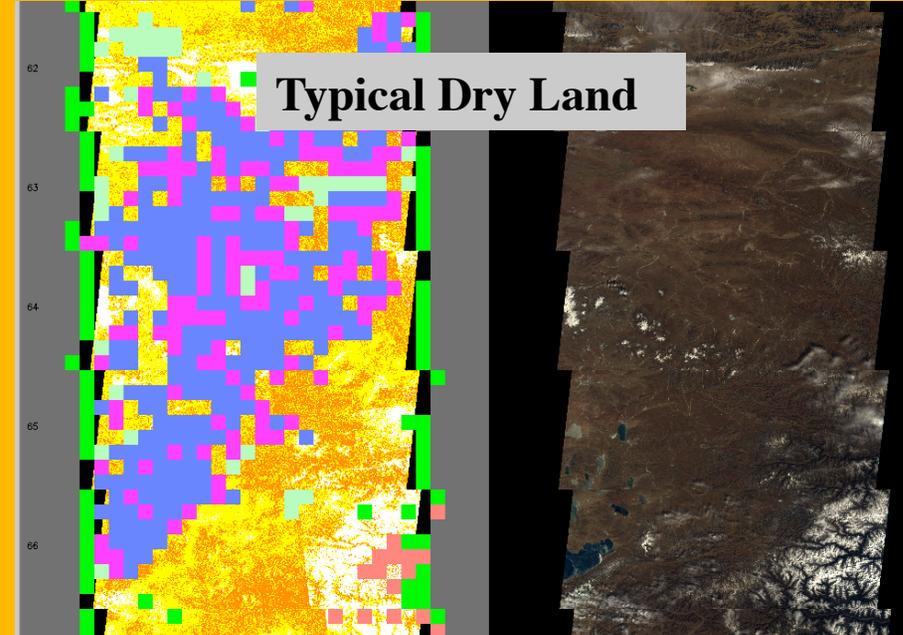
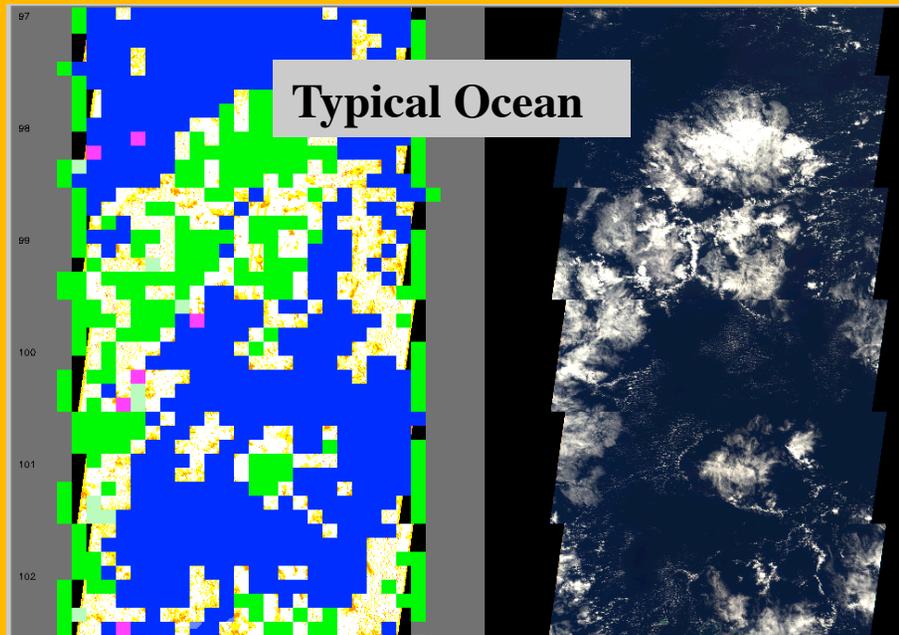
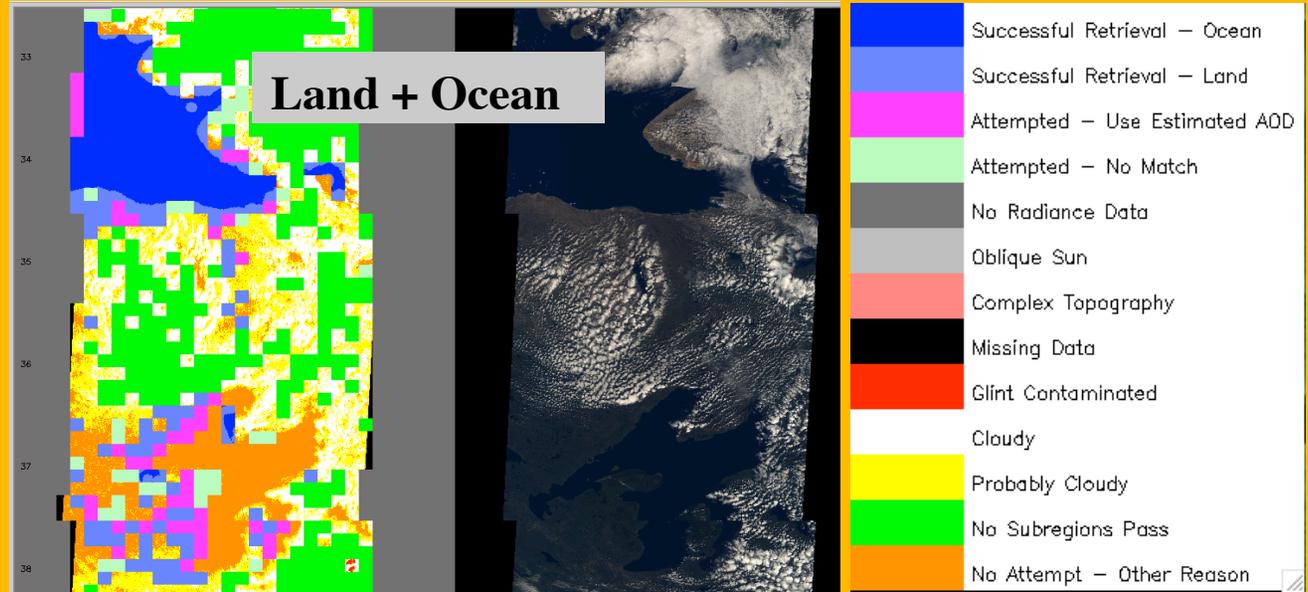


This is now a *quantitative* matter: *What precisions & accuracies are needed to identify, and to assess, global and regional trends in aerosol forcing, etc.?*

Maps Showing MISR *Retrieval Status Distribution*

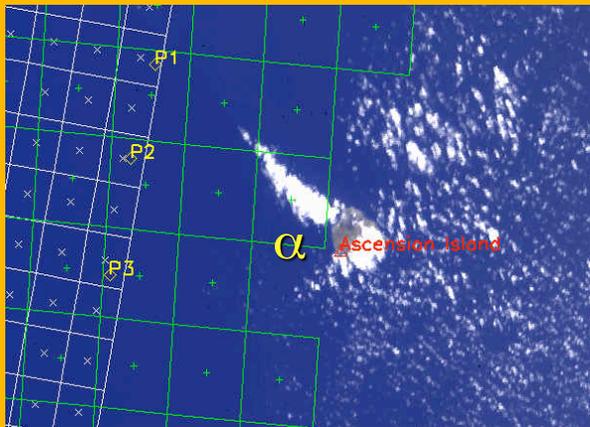
Overall, about **15%** of Earth's surface produces successful MISR automatic aerosol retrievals

Dark blue = Ocean retrieval
Light blue = Land retrieval

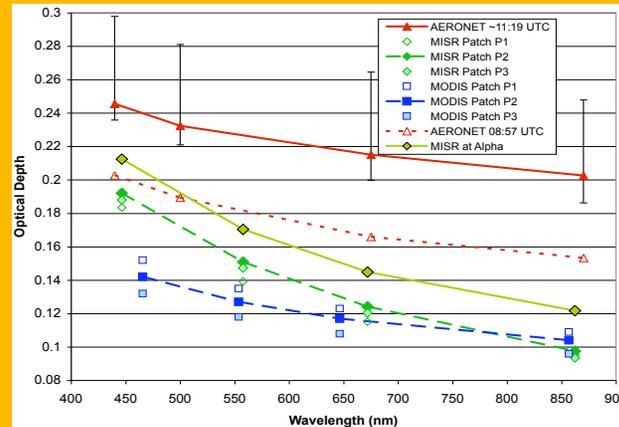


MISR-MODIS-AERONET *Sampling* Differences

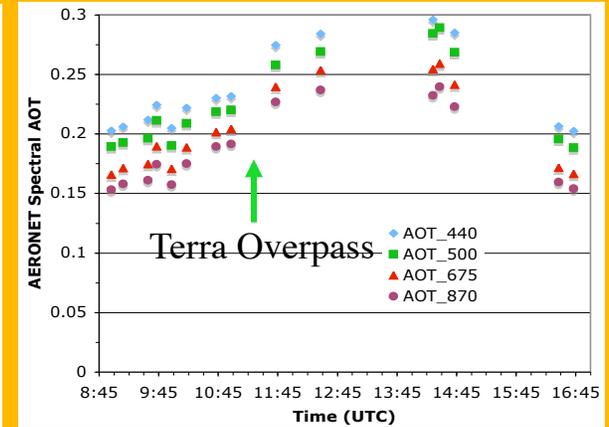
[Ascension Island 18 February 2005]



Sampling: **MISR**; **MODIS**; **AERONET**



AOT Snapshot: **AERONET** > **MISR** > **MODIS**



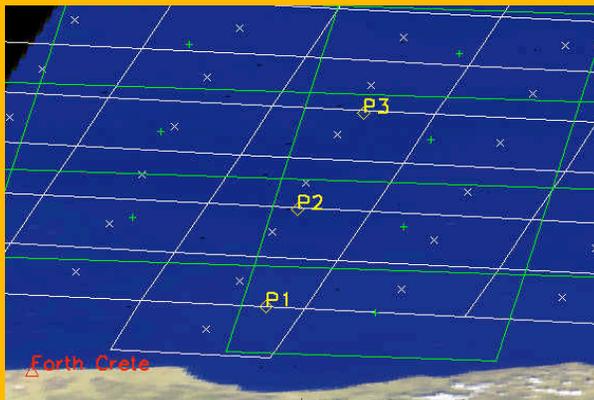
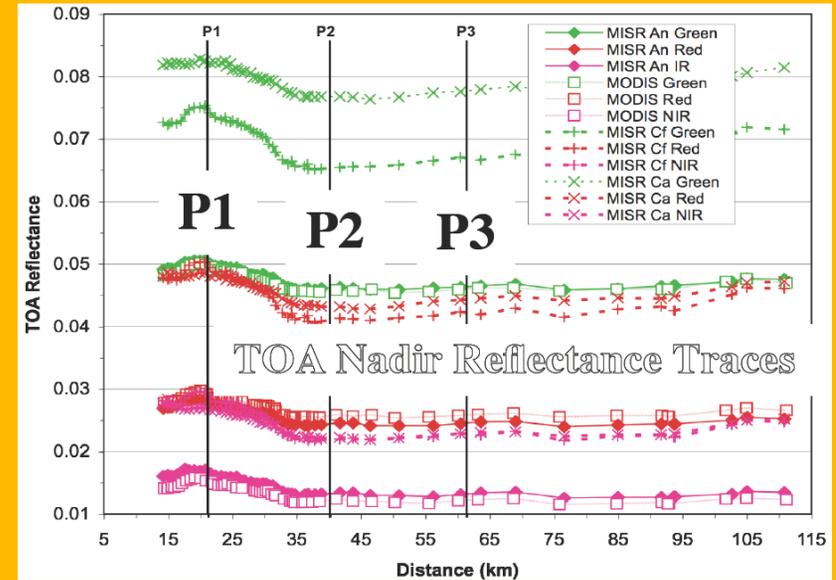
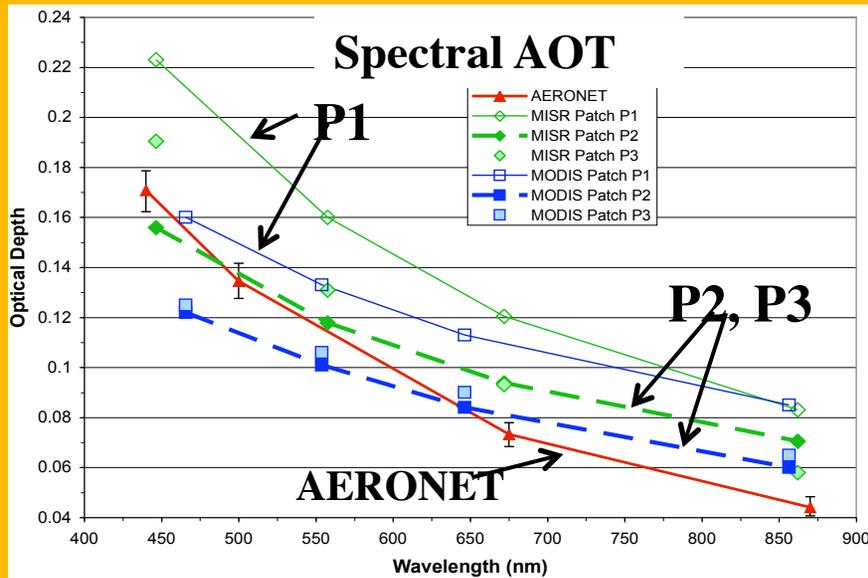
AERONET Time Series - Changing AOT

Clean, maritime aerosol air mass, but AOT changes 60% across RH boundary

Using any one of these to represent the entire region AOT --> large errors
Taken together, they give a better picture...

MISR-MODIS assumed *Lower Boundary Condition* Differences

[Forth Crete 13 September 2003]



- $AOT_{mid-vis} > \sim 0.1$
- P2, P3 match AERONET to ~ 0.01
- P1 $\Delta_{AOT_{mid-vis}} \sim +0.03$ to 0.04
- P1 $\Delta_{refl} \sim +0.005$ [G, R, NIR]

*An $A_{0,558nm}$ increase, from 0.8% to 1.5%,
can account for the entire AOT difference*



NASA ER-2 w/AirMISR



**NASA P3-B
w/AATS-14**

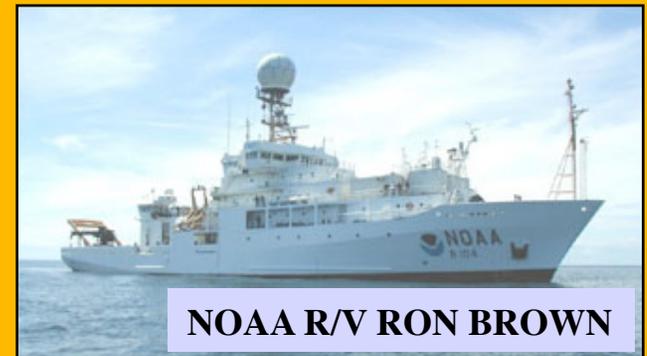
How much of this should we believe?



NASA B200 w/HSRL

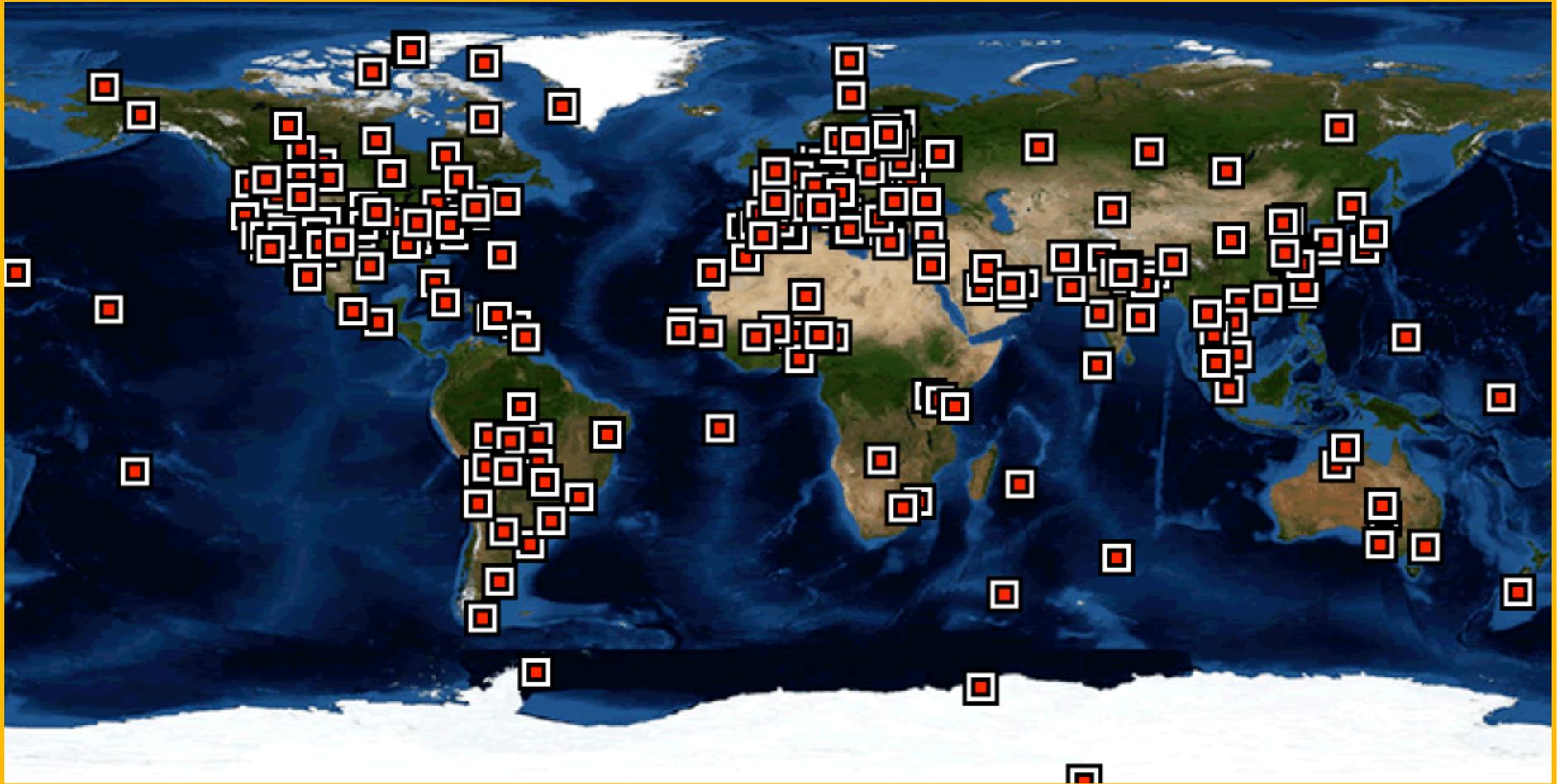


AERONET CIMEL



NOAA R/V RON BROWN

The AERONET Federated System of CIMEL Sun Photometers



Source: *AERONET* Web Site

MISR & MODIS Mid-Visible AOT Sensitivities Reported Currently

- MISR: **0.05 or 20% * AOT** overall; *better over dark water*
[Kahn et al., 2005]
- MODIS: **0.05 or 20% * AOT** over land
0.03 or 5% * AOT over dark water [Remer et al. 2005]

Based on AERONET coincidences (**cloud screened by both sensors**)

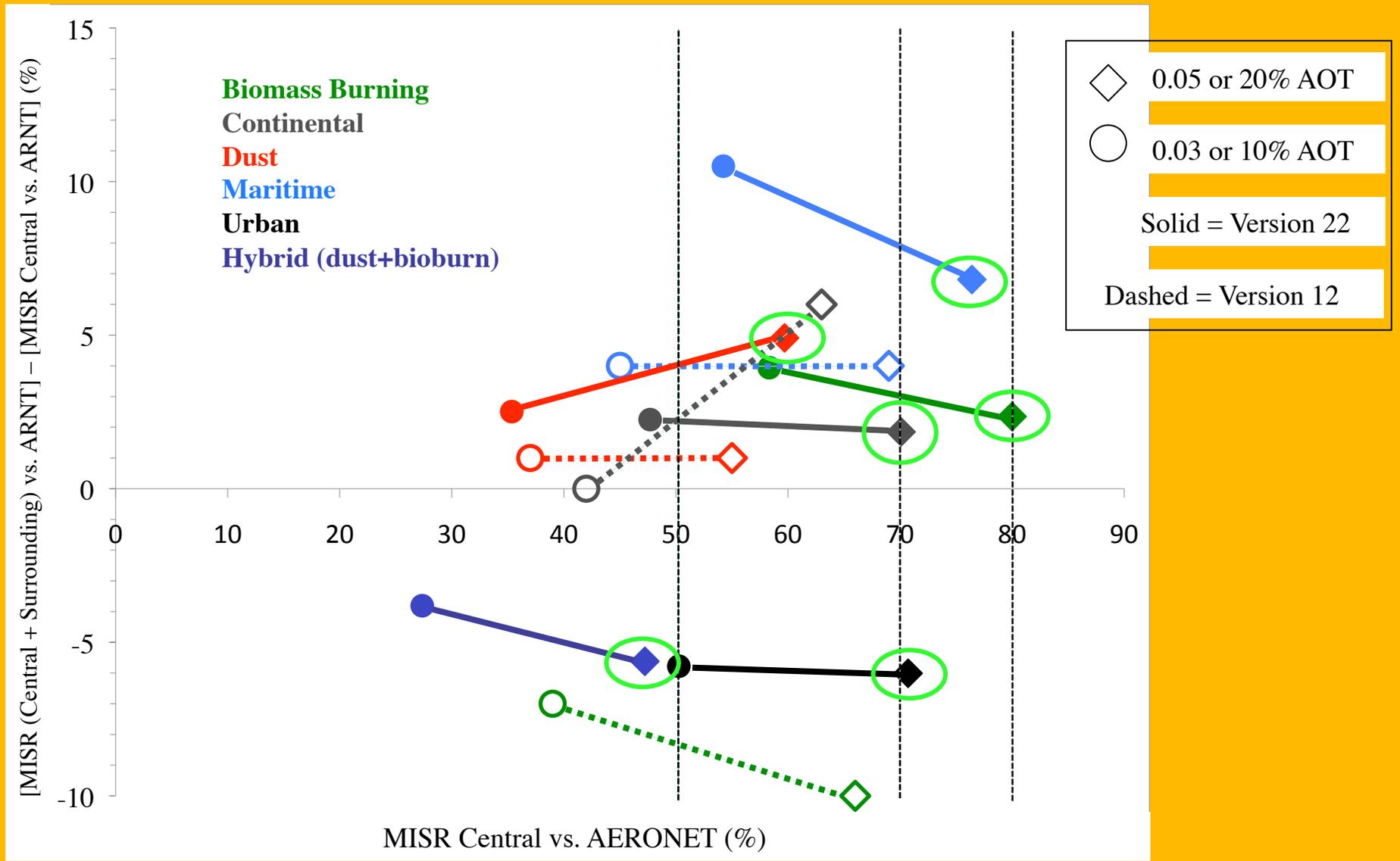
--> For global, monthly AOT, AEROCOM uses

MISR over land, MODIS over water

Direct Radiative Forcing: Need AOT to $\lesssim 0.02$

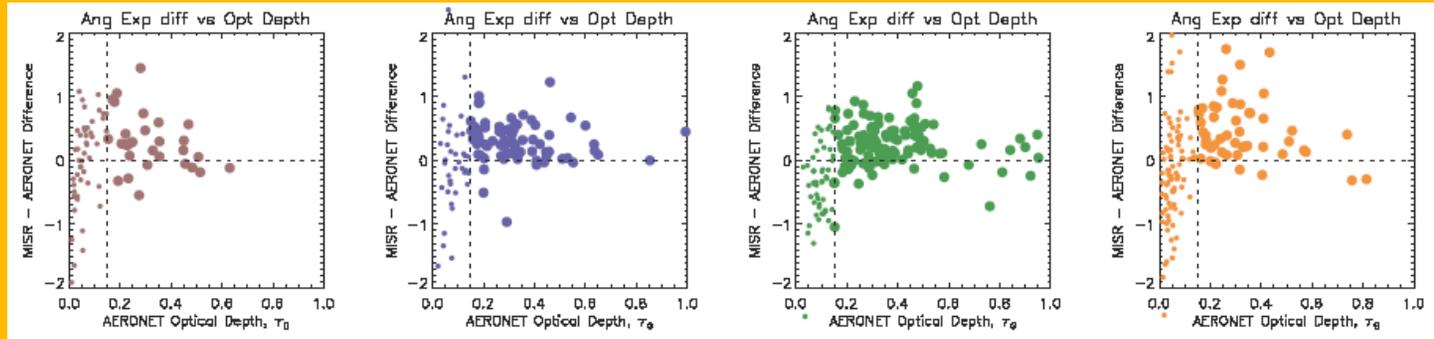
MISR-AERONET AOT Comparison for 3,605 Coincidences

Stratified by expected aerosol air mass type

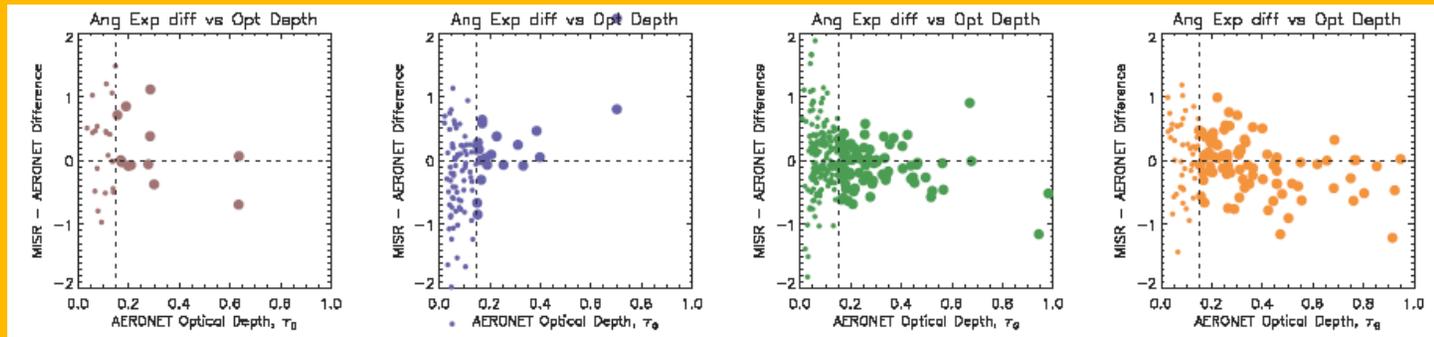


MISR - AERONET *Angstrom Exponent* vs. AERONET AOT

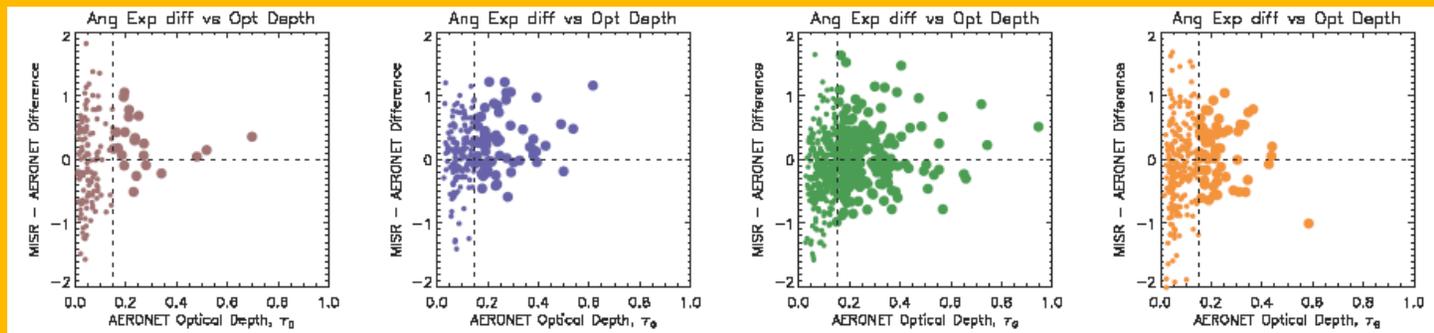
486
Dust Location
Events



493
Biomass
Burning Location
Events



1,055
Continental
Location
Events



N Winter

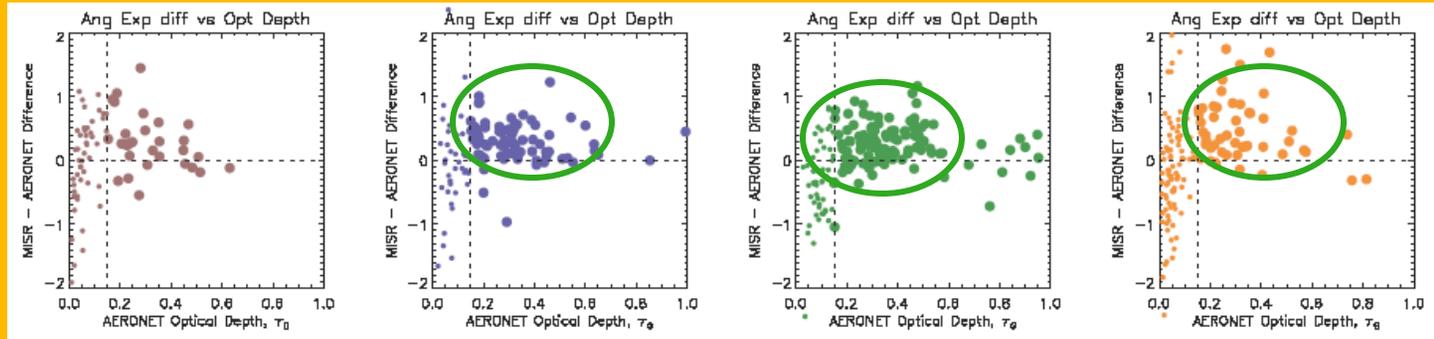
N Spring

N Summer

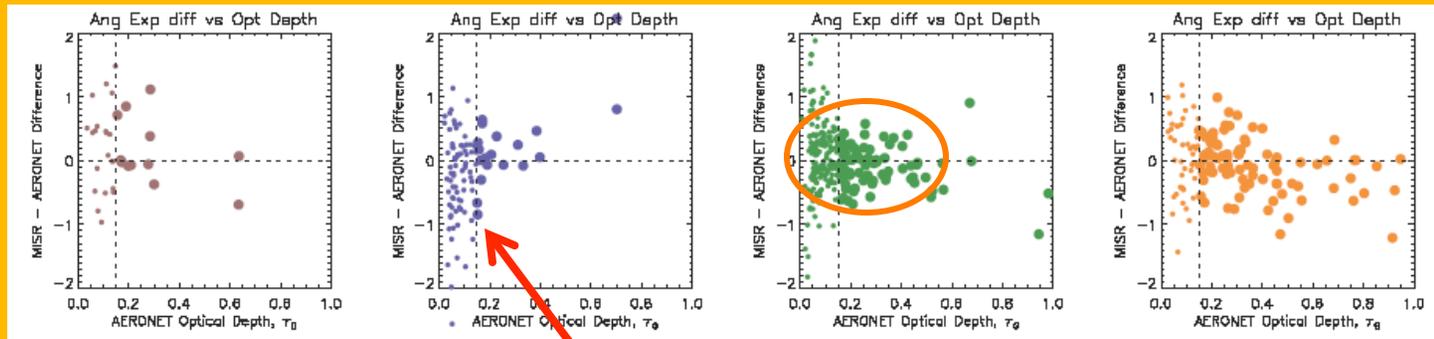
N Autumn

MISR - AERONET *Angstrom Exponent* vs. AERONET AOT

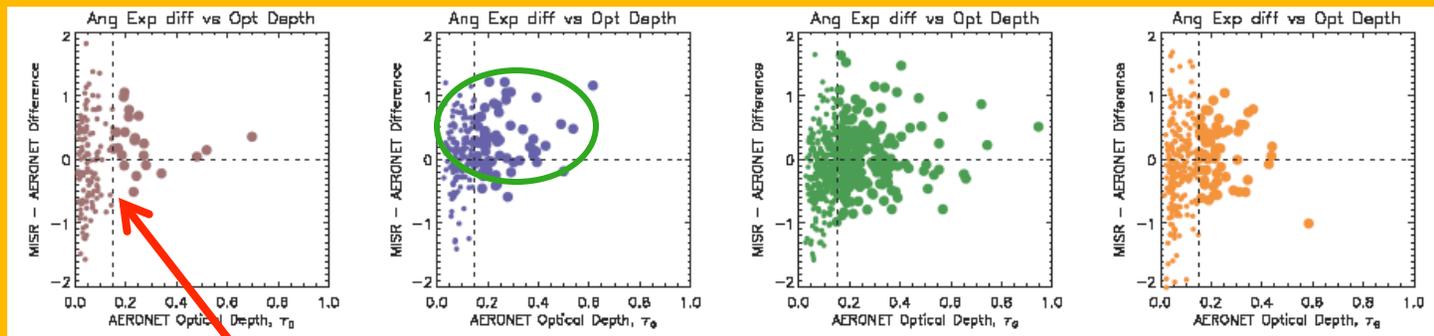
486
Dust Location
Events



493
Biomass
Burning Location
Events



1,055
Continental
Location
Events



N Winter

N Spring

N Summer

N Autumn

MISR *Non-spherical Fraction* AOT vs. AERONET AOT for 486 Dusty Location Events

0 < AOT < 0.1

Increasing AOT →

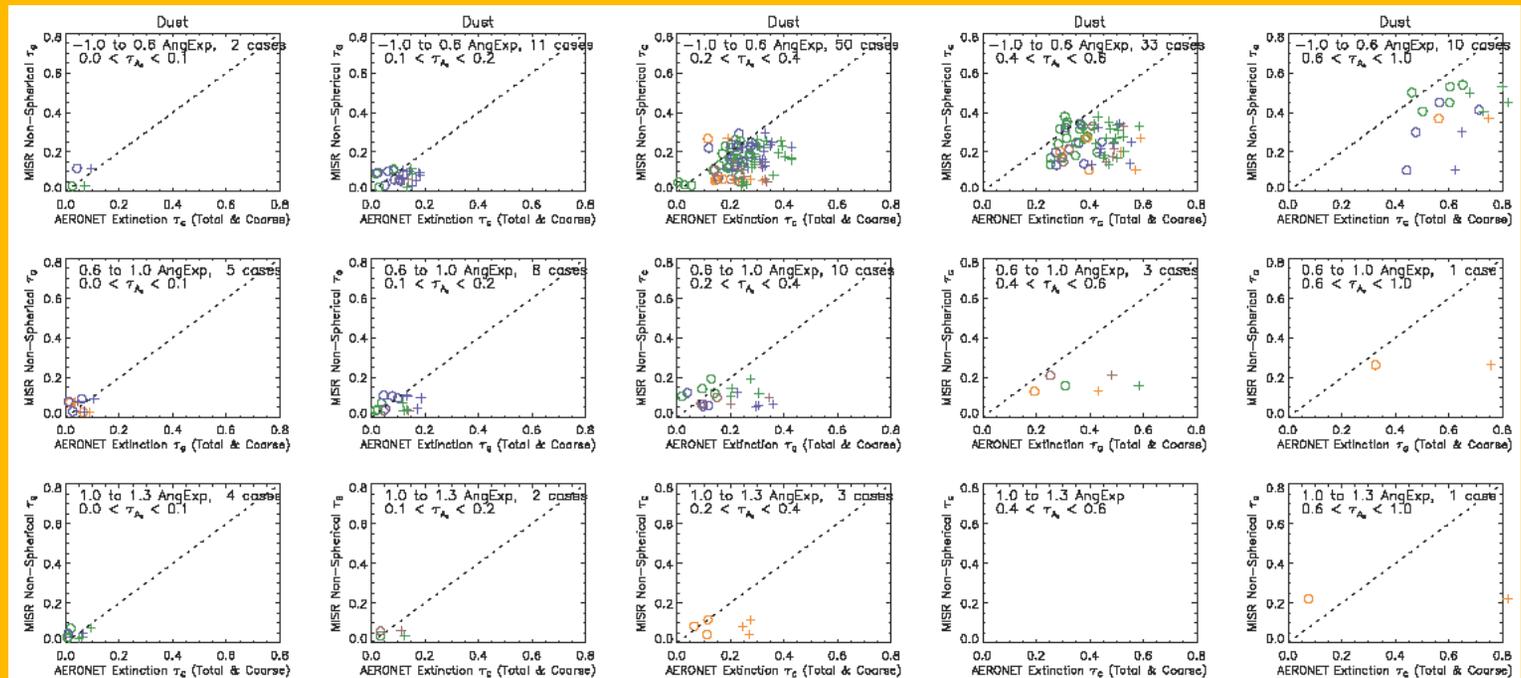
0.6 < AOT < 1.0

-1 < ANG < 0.6



Increasing Size
(decreasing ANG)

1 < ANG < 1.3



MISR *Non-spherical Fraction* AOT vs. AERONET AOT for 486 Dusty Location Events

0 < AOT < 0.1

Increasing AOT →

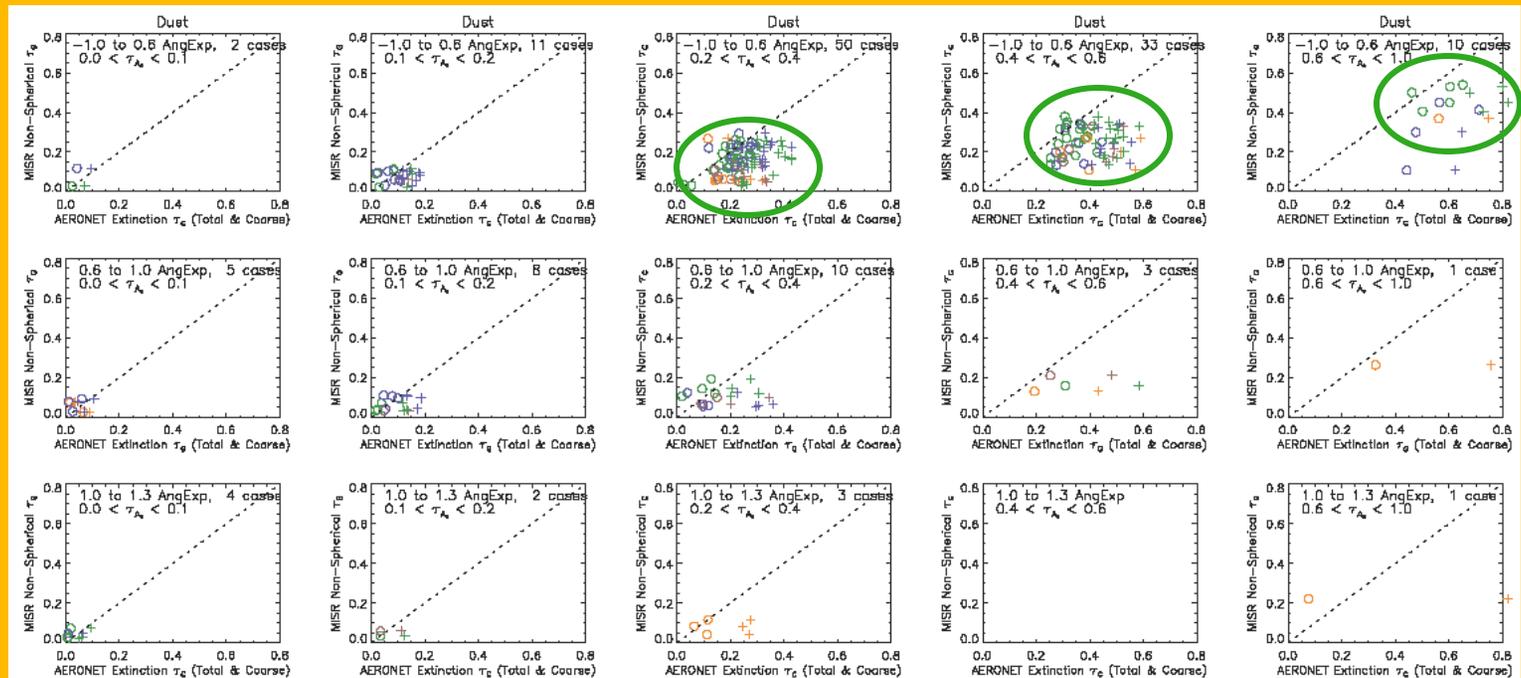
0.6 < AOT < 1.0

-1 < ANG < 0.6



Increasing Size
(decreasing ANG)

1 < ANG < 1.3



MISR vs. AERONET SSA for 493 Biomass Burning Location Events

Increasing AOT 

$0 < \text{AOT} < 0.1$

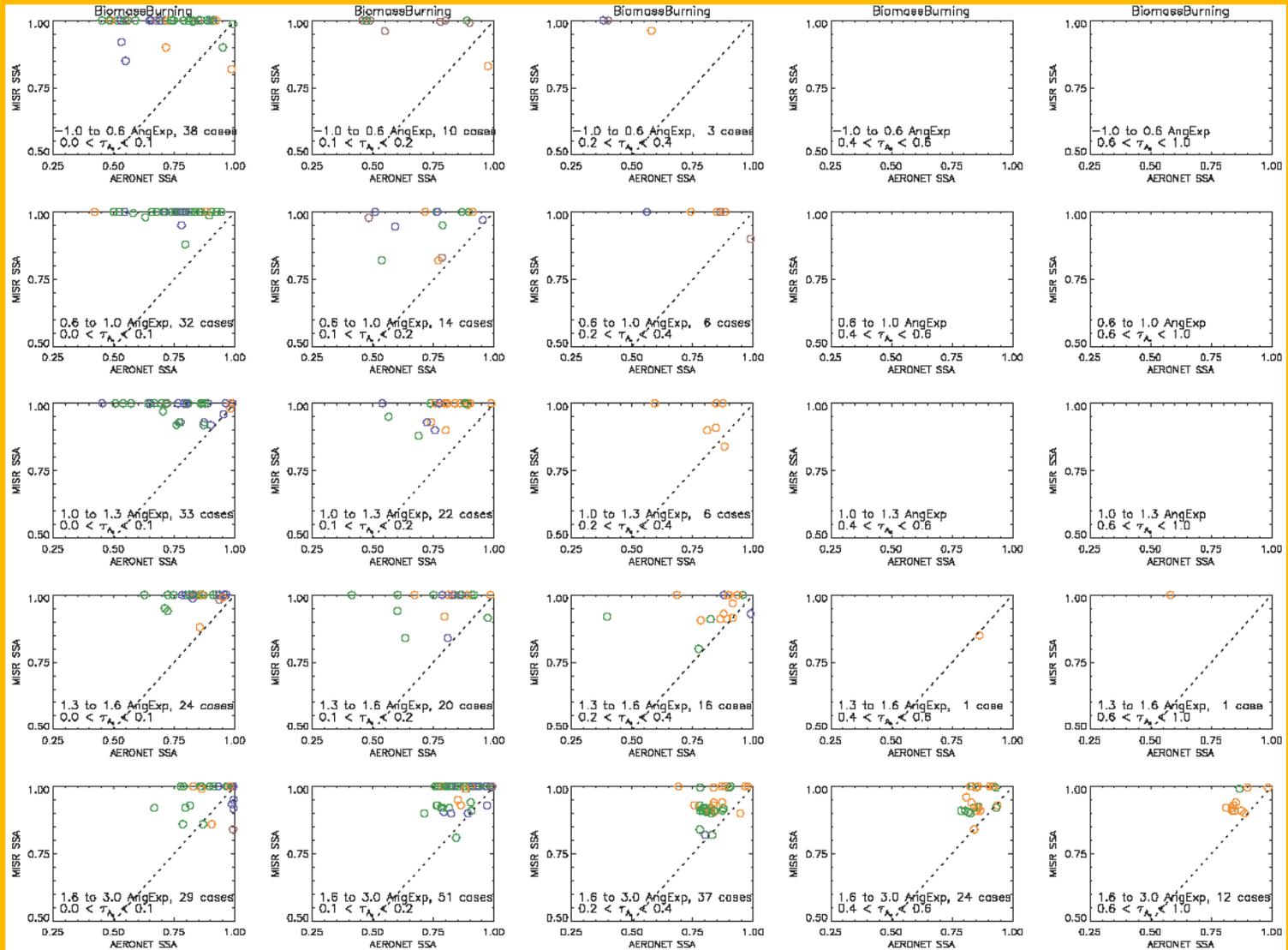
$0.6 < \text{AOT} < 1.0$

$-1 < \text{ANG} < 0.6$



Increasing Size
(decreasing ANG)

$1.6 < \text{ANG} < 3$



MISR vs. AERONET SSA for 493 Biomass Burning Location Events

0 < AOT < 0.1

Increasing AOT →

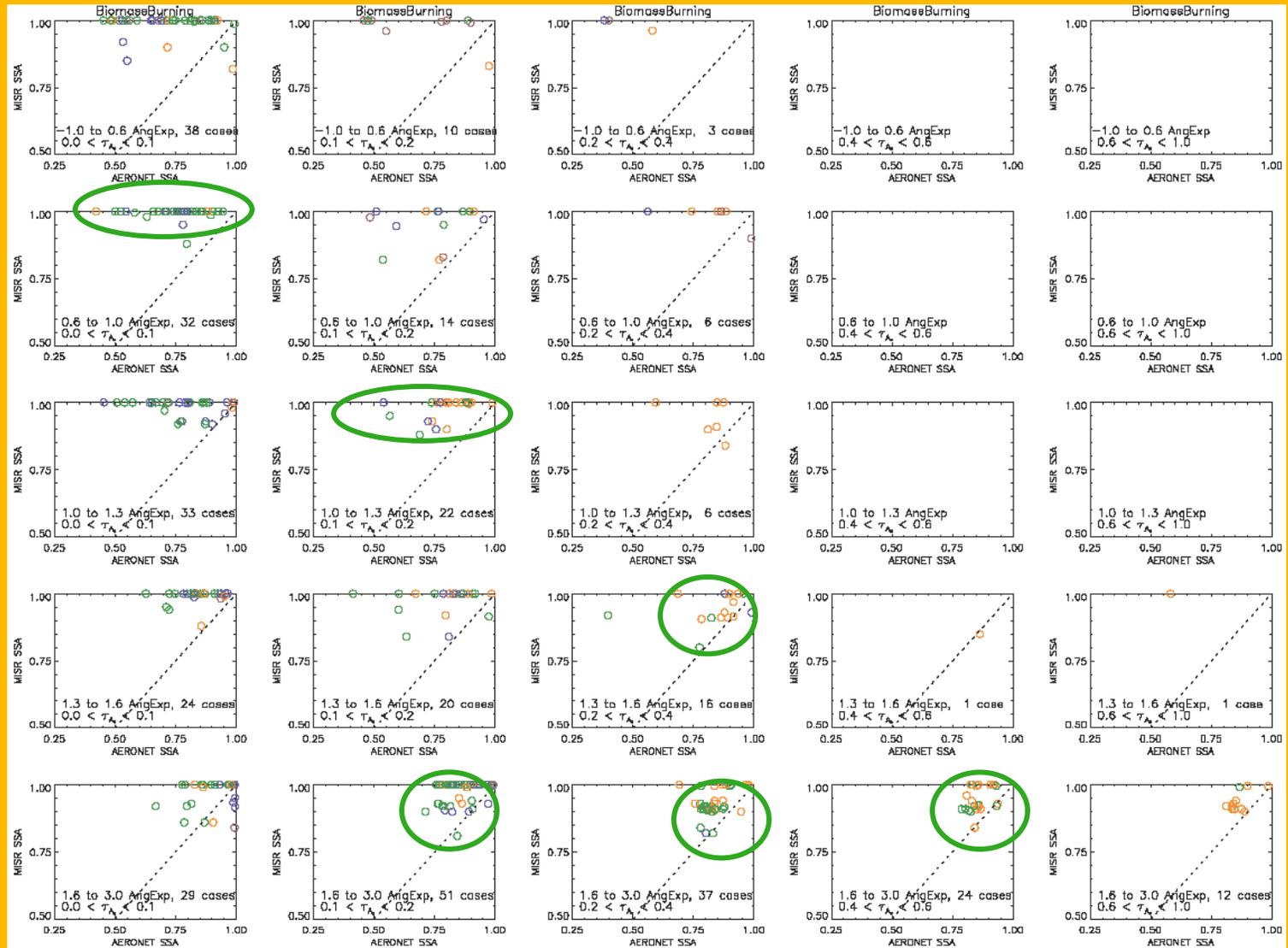
0.6 < AOT < 1.0

-1 < ANG < 0.6



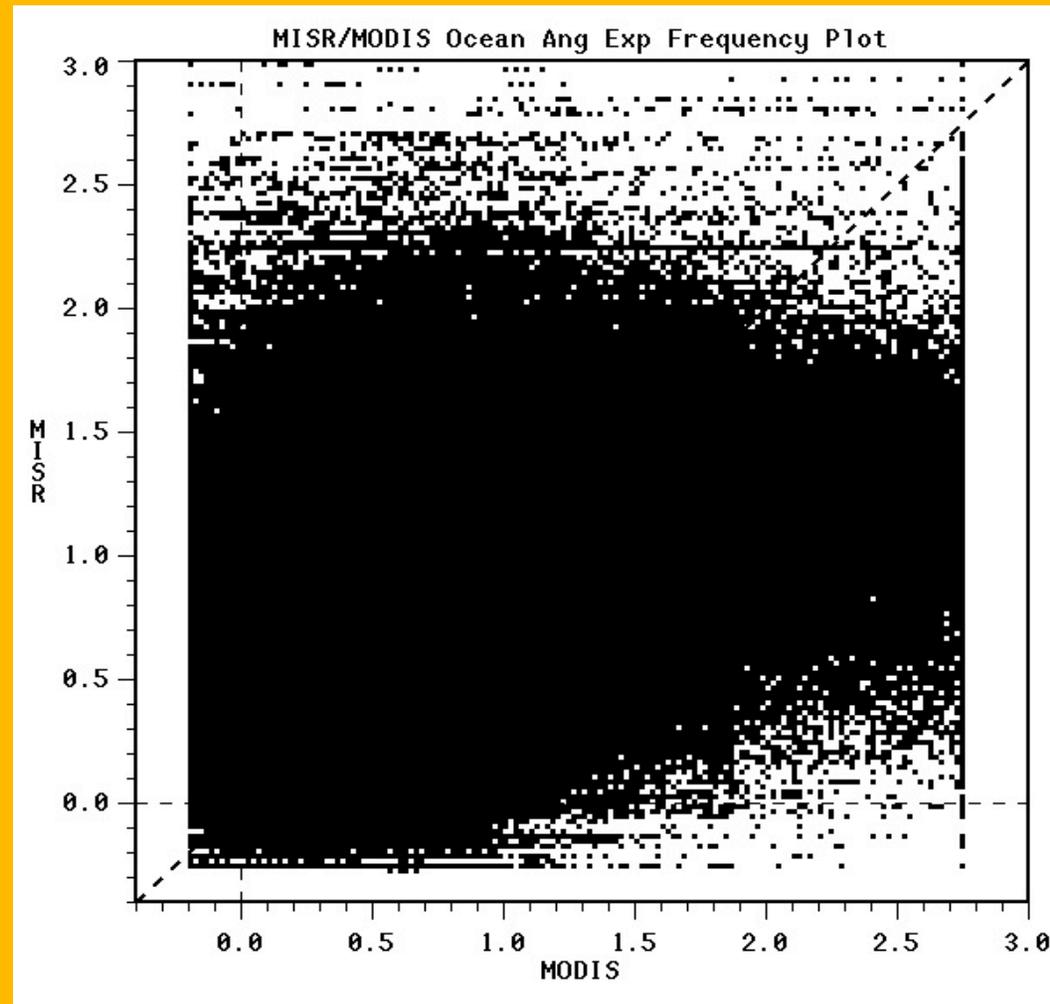
Increasing Size
(decreasing ANG)

1.6 < ANG < 3



MISR-MODIS *Angstrom Exponent over Ocean*

[MISR V22 vs. MODIS/Terra Collection 5; January 2006 Coincident Data]

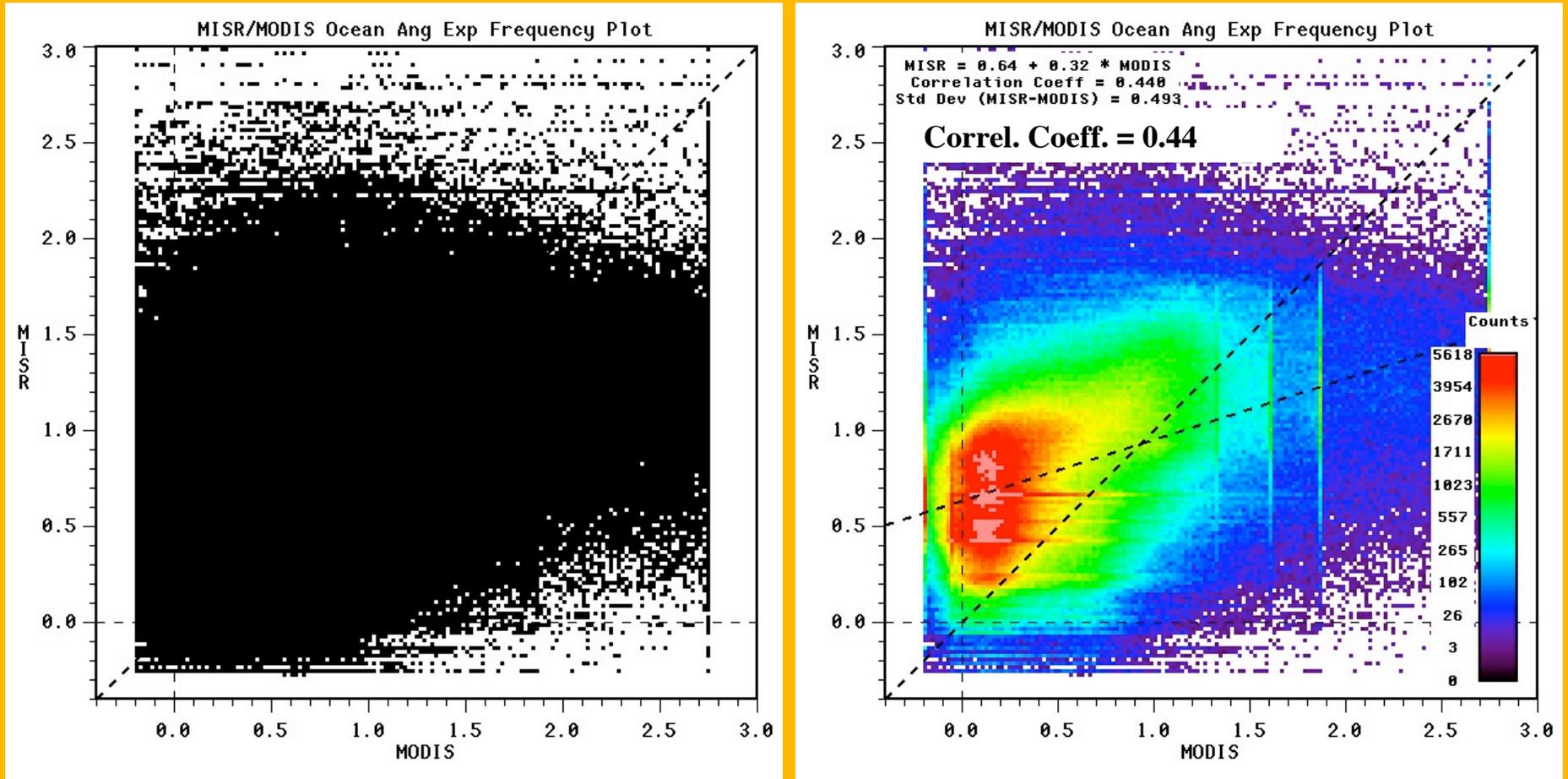


“We show that the MODIS and MISR Angstrom Exponent datasets reveal essentially no correlation.”

Liu & Mishchenko, JQSRT 2008

MISR-MODIS *Angstrom Exponent over Ocean*

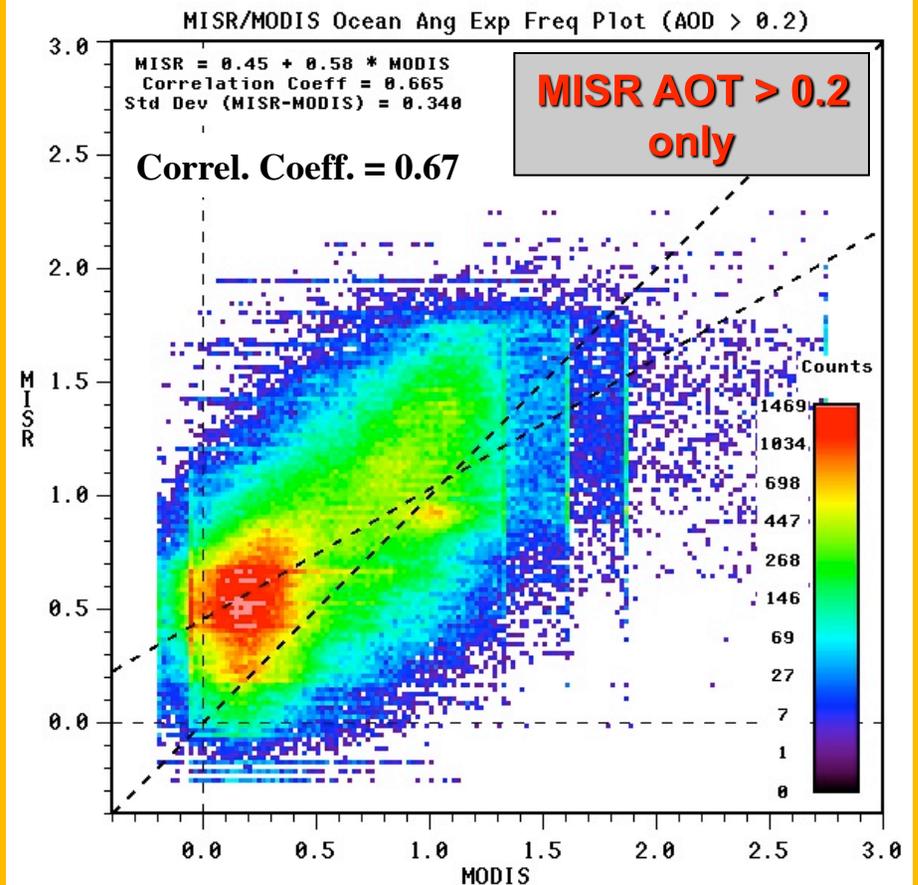
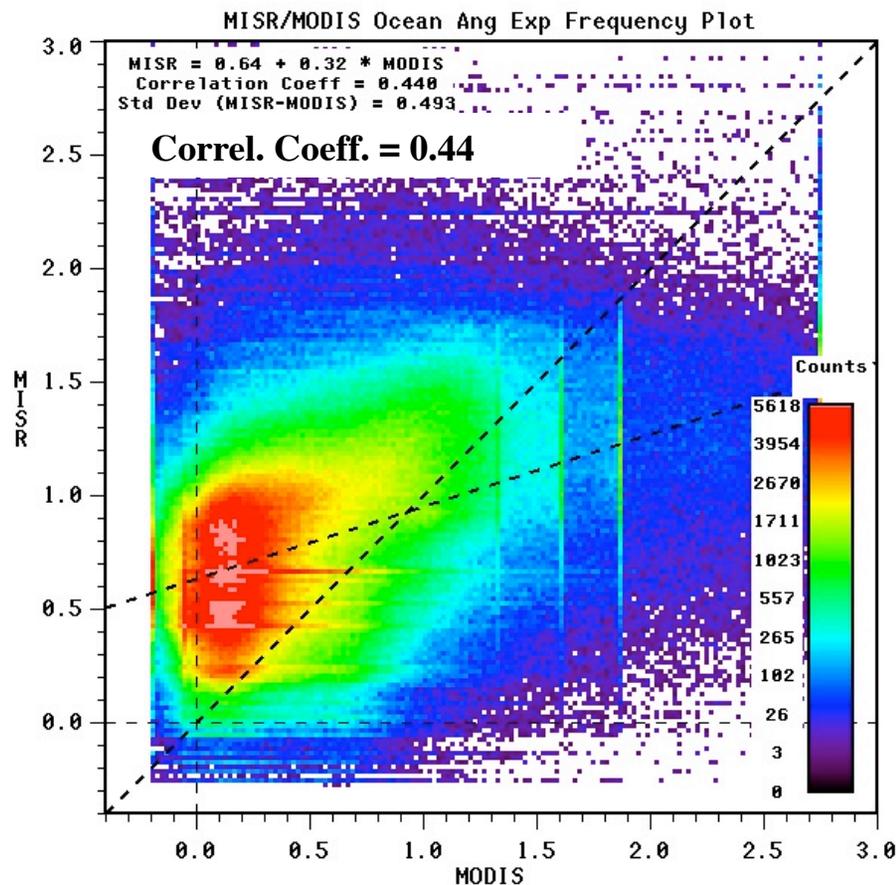
[MISR V22 vs. MODIS/Terra Collection 5; January 2006 Coincident Data]



Actual point density varies by over *three orders-of-magnitude* –
MISR ANG is systematically larger, but these values are sufficient to
distinguish aerosol air masses dominated by Fine or Coarse particles

MISR-MODIS *Angstrom Exponent over Ocean*

[MISR V22 vs. MODIS/Terra Collection 5; January 2006 Coincident Data]



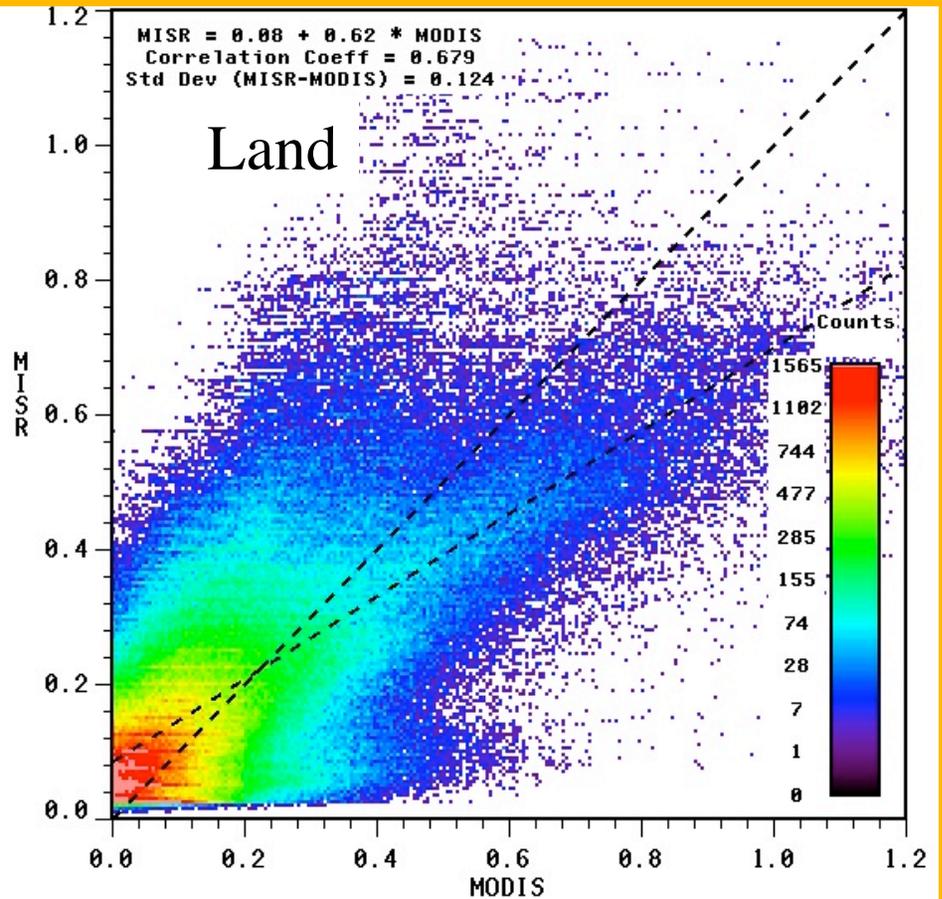
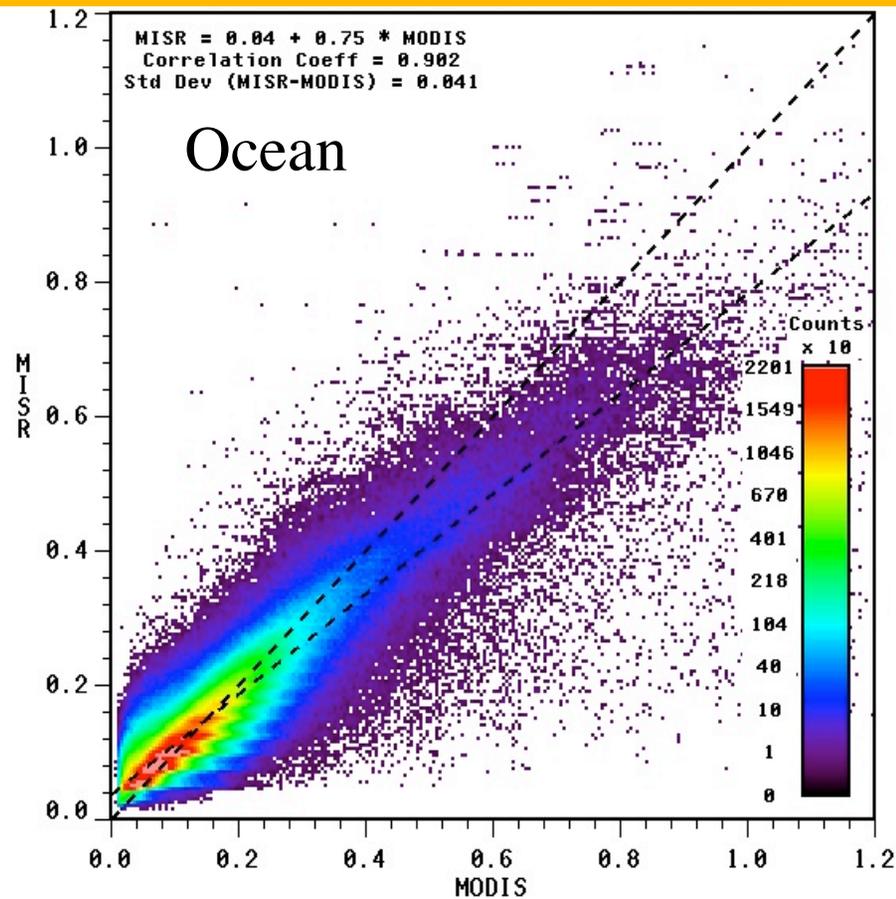
For AOT < ~0.2, poor particle property discrimination → Many mixtures pass → MISR ANG ~ 1

ANG distinguishes aerosol air masses dominated by *Fine or Coarse* particles

Note: *Over Land*, MODIS does NOT retrieve a quantitative Angstrom Exponent

MISR-MODIS *Aerosol Optical Depth* Comparison

[MISR V22 vs. MODIS/Terra Collection 5; January 2006 Coincident Data]



Over-ocean regression coefficient **0.90**

Regression line slope 0.75

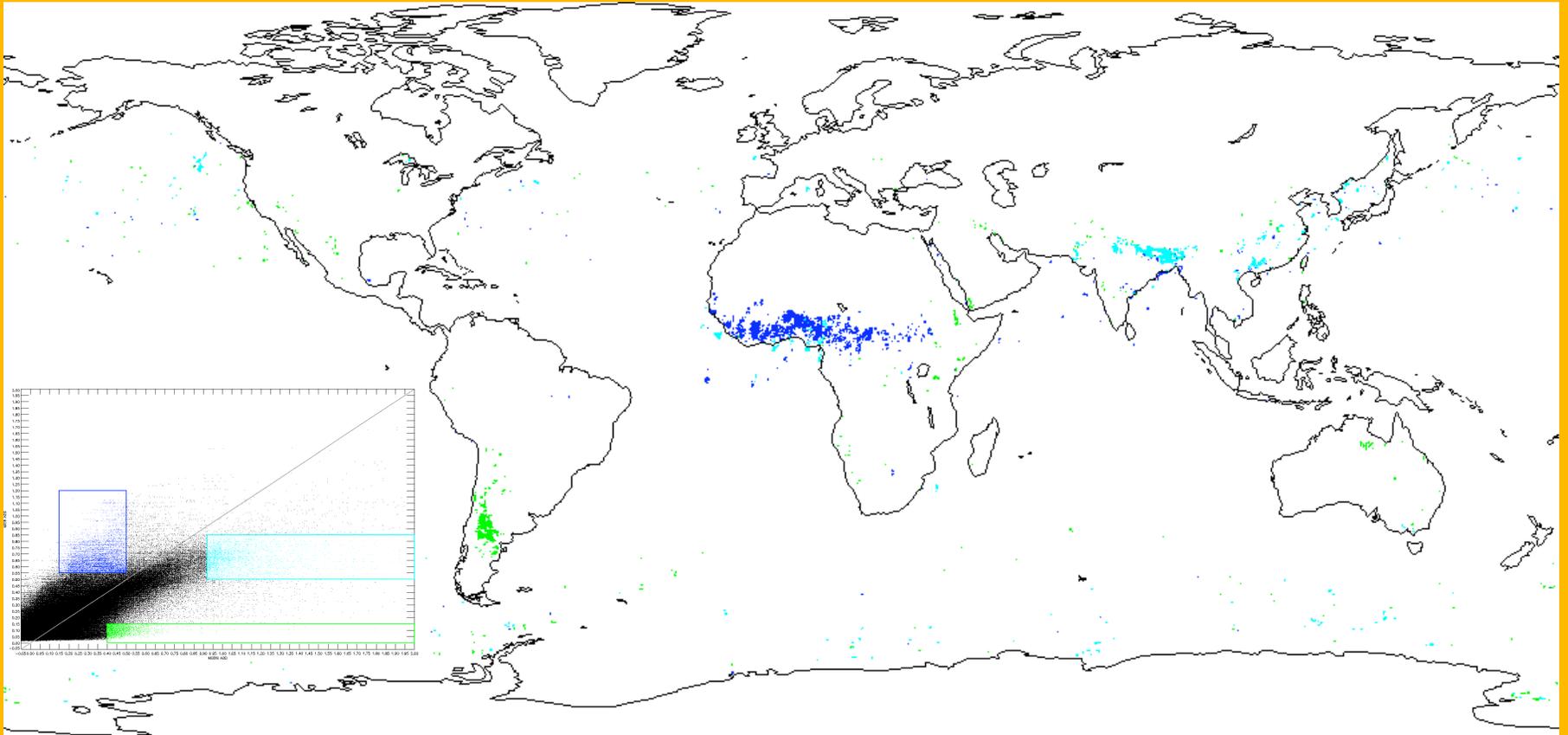
MODIS QC ≥ 1

Over-land regression coefficient **0.68**

Regression line slope 0.62

MODIS QC = 3

MISR-MODIS Coincident AOT ***Outlier Clusters***



Dark Blue [MISR > MODIS] – N. Africa *Mixed Dust & Smoke*

Cyan [MODIS > MISR, AOD large] – Indo-Gangetic Plain *Dark Pollution Aerosol*

Green [MODIS >> MISR] – Patagonia and N. Australia *Unscreened Bright Surface*

All are known, published issues → Outliers are better understood than Li & Mishchenko suggest

CURRENT STATE OF MISR-MODIS AEROSOL CAPABILITY

What we can do routinely now with satellite data

- **AOT over water and land**, except scattered *cloudy* regions, some *snow & ice* situations, *Case 2 water*
- **Medium/large** aerosol ratio over water; [MODIS; possibly **dust** from **pollution** from **small** particles]
- **Spherical vs. Non-spherical** [MISR; **plates** from **grains** from **spheres** at least in some cases]
- **Aerosol Layer Height** [TOMS uv, GLAS, CALIPSO]
- **Aerosol Plume Height** to ~0.5 km [MISR; mainly forest fire, volcano, and dust source regions]
- **Fire Occurrence** [MODIS, AVHRR and other instruments w/mid-IR channels]

What we can do now in many cases with current algorithms, could do routinely

- **3-5 size bins** over land and water [MISR; algorithm upgrades pending]
- **2-4 single-scattering albedo groupings** [MISR; algorithm upgrades pending]
- Aerosol amount & properties over **Case 2 waters** [MISR; algorithm development underway]

There is more to be said about **other of the newer satellite instruments** as well:

POLDER, CERES, GLAS, AIRS, CALIPSO, (GLORY – after launch), etc.

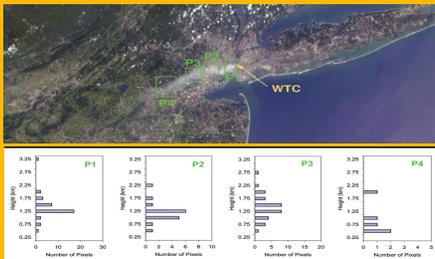
The Main Points – Current MISR (Version 22) Aerosol Product

- **AOT Coverage** – *Global but not statistical* on a monthly basis
- **AOT Accuracy** – Maintained even when particle property information is poor
- **Particle Size** – *~3 groupings reliably*; quantitative results vary w/conditions
- **Particle Shape** – *spherical vs. non-spherical robust*, except for coarse dust
- **Particle SSA** – useful for *qualitative* distinctions
- **Aerosol Type Information** – diminished when *AOT < 0.15* or 0.2
- **Particle Property Retrievals** – *improvement expected* w/algorithm upgrades
- **Aerosol Air-mass Types** – *more robust* than individual properties

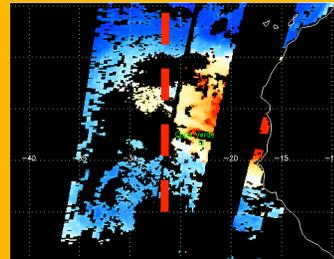
PLEASE READ THE QUALITY STATEMENT!!!

MISR Aerosol Product Applicability

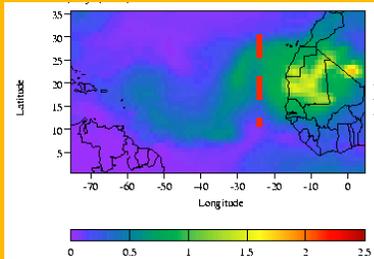
- On a *Monthly, Global* basis, the MISR Aerosol Data Set provides **Limited Statistical Representation** of AOT & Type
 - **Cloud-Free Bias**
 - **High-AOT Bias** for Aerosol Type
 - Overall **Sampling** – gradients, plumes, diurnal variations
- For some applications, this **is NOT critical**
 - **Plume Heights**
 - AOT contours to constrain **Aerosol Transports**
 - Aerosol **Air Mass Type Mapping**



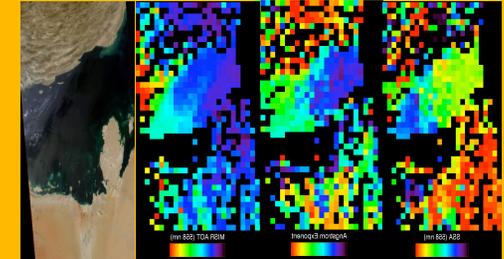
WTC Smoke Plume Heights



MISR & MODIS AOD



NAAPS Dust



MISR UAE-2 Aerosol Air Masses

Prospects

- For some *Climate-change applications*, sampling and accuracy limitations *can be important*
 - *Trends Analysis*
 - Large-scale, aerosol *Direct Radiative Forcing* calculations
 - *Indirect Effects* of aerosols on clouds (in *many* ways)
[size bias (CCN), near- & below-cloud distribution bias, size & chemistry detail]
- Reducing uncertainties sufficiently for these applications *cannot* be done with *Satellite data ALONE*
 - *Try anyway* – useful clues; but *know the limitations*
 - Combine with:
 - * *Surface Remote Sensing* (temporal but poor spatial coverage)
 - * *In Situ Sampling* (detail, but poor spatial & temporal coverage)
 - * *Models*